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ANNUAL REPORT

to

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

for

CHARACTERIZATION OF THE PHYSICO-CHEMICAL PROPERTIES
OF POLYMERIC MATERIALS FOR AEROSPACE FLIGHT

(NASA-CR-156116) CHARACTERIZATION OF THE
PHYSICO-CHEMICAL PROPERTIES OF POLYMERIC
MATERIALS FOR AEROSPACE FLIGHT Annual
Report (Bowie State Coll., Md.) 85 p HC
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March 17, 1978

Date

Bowie State College
Bowie, Maryland 20715



INTRODUCTION

The major source of contamination in spacecraft is internal. Outgassing of polymers, greases, and other organic materials at low pressures in space and test causes contamination. Condensation of contaminants on cold surfaces, such as particle detectors or optical surfaces will seriously reduce the efficiency of such units and give erroneous results. In addition, excessive outgassing may lead to corona inception and multipacting and can modify physical properties of the polymers.

Materials intended for use in spacecraft are routinely tested at low pressures, and outgassed substances are condensed on cold surfaces at liquid nitrogen temperature - 196° C. These condensates are then analyzed by infra-red spectroscopy, and gas chromatography-mass spectroscopy.

At GSFC, the polymers are tested and allowed to outgas isothermally at 125° C and 10^{-6} torr or less. Valuable information can be obtained by extending the temperature range below and above 125° C. The performance, of substances of interest to NASA, was investigated by thermogravimetric analysis (TGA) from room temperature to 450° C or until the substance decomposed.

Thermogravimetric analysis of a substance is a useful technique for studying its thermal nature in both static and dynamic thermal environments. It gives considerable insight into the stability and characterization of substances and the changes they undergo in varying thermal environments.

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PROCEDURE

Thermogravimetric analyses are run on a DuPont 950 Thermogravimetric Analyzer. With the final completion of the moving of the equipment and shifting to a vacuum atmosphere, all runs were performed at standard pressure of about .03 microns (3×10^{-5} torr).

A new procedure is currently in use with sample #6995. The new thermal program proceeds as follows:

- Each sample is run isothermally at ambient temperature (20° C to 30° C) for one-half hour or ten minutes after reaching minimum pressure.
- The temperature is then programmed to rise at maximum rate (approximately 50° C/min.) to the isotherm temperature. The recorder is set to measure temperature vs. weight during this phase. We thus measure overshoot as the sample is heated. We routinely mark the graph at 60 second intervals during the heat-up phase. This is accomplished by momentarily depressing the weight axis null button.
- The sample is then held isothermally at the desired temperature (125° C, 200° C, 250° C) for 24 hours and the weight is measured as a function of time. The final step, the temperature decomposition phase, is programmed to rise at 3° C to 4° C per minute from the established isothermal temperature to 450° C or until the sample decomposes.
- The four thermal steps are:
 1. Room temperature isotherm.
 2. Room temperature to isotherm temperature, with the unit previously set to stop at the desired isotherm temperature.
 3. Isothermally at desired temperature for 24 hours.

4. Sample is heated from isotherm (125° C, 200° C, 250° C) to decomposition.

DISCUSSION OF TABLES

The following is an explanation of columns 3, 4, 5, 6, 7, and 8 in the tables:

Column 3

Shows the weight loss of the sample
at ambient temperature - (20° C - 30° C)

Columns 4 and 5

As the sample is heated to the isotherm temperature, the rate of weight loss increases. This rapid rate of weight loss persists for a short time after the isotherm temperature has been reached. The rate of weight loss then decreases and levels off. There appears to be a loss of volatiles during the heating phase with some of the volatiles coming off after the isotherm has been reached. These two portions, that which comes off before the isotherm is reached, and that which comes off at the isotherm, are listed separately in columns 4 and 5. The sum of columns 4 and 5 gives the total weight of these volatiles lost.

Column 6

After the weight curve levels off, there is a continuing slow loss of weight at the isotherm. This weight loss is measured for one day, and the values are listed in column 6.

Columns 7 and 8

After one day, the temperature is programmed to rise at 3°C to 4°C per minute. The recorder graphs temperature vs. weight. The graph starts as a straight line; at some temperature the graph curves down, meaning that the rate of weight loss is increasing. The straight line portion of the graph is extrapolated. Column 7 lists the temperature at which the line curves down; the temperature at which the rate of loss is noticeably greater than the constant rate. Column 8 lists the temperature at which the actual curve is 0.2mg (or 0.2 inches) below the extrapolated line. This measurement is an arbitrary one and was chosen because it is less subjective than the figure in column 7 and gives another point of comparison between different samples.

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FOUR FOOT FRAME

SAMPLE AND #	WEIGHT	LOSS C ROOM TEMP	LOSS R.T TO 125° C	LOSS TO LEVEL OFF
69 (RTV-600	102	.04 mg	.08 mg	0.13 mg
70 (Solithane (100° C)	60.3 mg	0.11 mg	.07 mg	0.59 mg
71 (RTV-600	97.7 mg	0.1 mg	0.1 mg	.91 mg
72 (Untreated Ne 102	75.3 mg	0.1 mg	---	---
73 (Untreated Ne 102	73.1 mg	.05 mg	---	.05 mg
74 (Ne 102)	65.1 mg	00	---	---
75 Ne Untreated 102	99.4 mg	.38 mg	---	---
76 Ne 102 Baked	103.7 mg	---	---	.08 mg
79 Ne Untreated 102	98.02 mg	---	---	.16 mg
81 NE 102 Baked	98.02 mg	---	---	.16
82 Ne 110	101.28 mg	---	---	see # 83
83 Ne 110	97.56 mg	---	---	.2 mg
84 1018 tape	101.68 mg	---	---	.22 mg
88 1018 tape	88.25 mg	---	---	---
89 Untreated 0060 tape	99.35 mg	---	---	---

FOURTH PLATE
2

LOSS R.T TO 125° C	LOSS TO LEVEL OFF	LOSS @ 125° C	TEMP.. DECAY	TEMP. 0.2 mg DEPARTURE
.08 mg	0.13 mg	0.26 mg	170° C	708° C
.07 mg	0.59 mg	0.20 mg	358° C	365° C
0.1 mg	.91 mg	1.0 mg	----	----
---	---	0.1 @ 45° C	100° C	110° C
---	.05 mg	---	105° C	115° C
---	---	---	---	---
---	---	.1 @ 45° C	---	---
---	.08 mg	.06 mg @ 45° C	110° C	125° C
---	.16 mg	.02 mg	105° C	133° C
---	.16	.02 mg @ 45° C	180° C	225° C
---	see # 83	see # 83	210° C	268° C
---	.2 mg	.04 @ 40° C	137° C	155° C
---	.22 mg	.04 mg	---	---
---	---	---	100° C	130° C
---	---	---	115° C	135° C

SAMPLE & #	WEIGHT	LOSS @ ROOM TEMP. .0	LOSS R.T TO 125° C	LOSS TO LEVEL OFF
# 90 Untreated 0080 Tape	99.2 mg	---	---	---
# 91 Untreated 1018 Tape	80.7 mg	---	---	---
#92 Untreated 0080 Tape	78.1 mg	---	---	---
# 94 Untreated 0080 Tape	89.5 mg	---	---	---
# 95 1018 Tape	91.54 mg	---	---	---
# 96 1018 Tape	121.25 mg			
#97 1018 Tape	112.5 mg	---	---	---
# 98 1018 Tape	112.5 mg	---	---	---
# 99 0080 Tape	113.0 mg	---	---	---
#101 0080 Tape	93.5 mg	---	---	---
#102 0080 Tape	64.8 mg	---	---	---
#106 Black Graphite Cloth	69.7 mg	--	to 105° .4 mg	---
#107 Adhesive (Epoxy)	40.6	.3 mg	---	---
#107a Black Graphite Cloth	43.90	.1 mg	to 105° .0 mg	.6 mg

FOLDOUT FRAME
1

LOSS R.T TO 125° C	LOSS TO LEVEL OFF	LOSS @ 125° C	TEMP. DECAY	TEMP. 0.2 mg DEPARTURE
---	---	---	90° C	125° C
---	---	---	100° C	150° C
---	---	---	90° C	130° C
---	---	---	105° C	127° C
---	---	---	100° C	125° C
			120° C	125° C
---	---	---	265°	310°
---	---	---	see # 97	see # 97
---	---	---	100° C	130° C
---	---	---	100° C	130° C
---	---	---	see #94	see #94
to 105° .4 mg	---	.2 mg	---	---
---	---	---	---	---
to 105° .0 mg	.6 mg	105° .08 mg	150° C	350° C

FOR FRAME

2

# SAMPLE AND #	WEIGHT	LOSS @ ROOM TEMP.	LOSS R.T TO 125° C	LOSS TO LEVEL OFF
# 108 Adhesive (Epoxy)	42.9 mg	.32	---	---
# 109 Epoxy Adhesive	109.85 mg	.70 mg	@ 105° C 0 mg	.70 mg
# 110 RTV 560/9811	160.9 mg	.05 mg	---	---
#111 RTV-560/9811	115.25 mg	.8 mg	.1 mg	---
#112 RTV-560-9811	116 mg	.9 mg	---	---

FORBODY FRAMES

**ORIGINAL PAGE 13
OF POOR QUALITY**

LOSS R.T TO 125° C	LOSS TO LEVEL OFF	LOSS @ 125° C	TEMP. DECAY	TEMP. 0.2 mg DEPARTURE
---	---	---	---	---
@ 105° C 0 mg	.70 mg	@ 105° C 0	200° C	215° C
---	---	---	---	---
.1 mg	---	---	---	---
---	---	---	---	---

FORBIDDEN CRANE

2

#69 KTV-600

mg

103

102

101

100

99

98

A

B

C

D

- A - Room Temperature
- B - Room Temperature to 75°C
- C - Isothermal at 75°C
- D - Heat to Destruction

0

A (minus Pericycle) 36

B (minus PC) 50

C (minus PC) 36

72

100

72

108

150

108

144

200

144

180

250

180

216

300

216

242

350

242

278

400

278

314

450

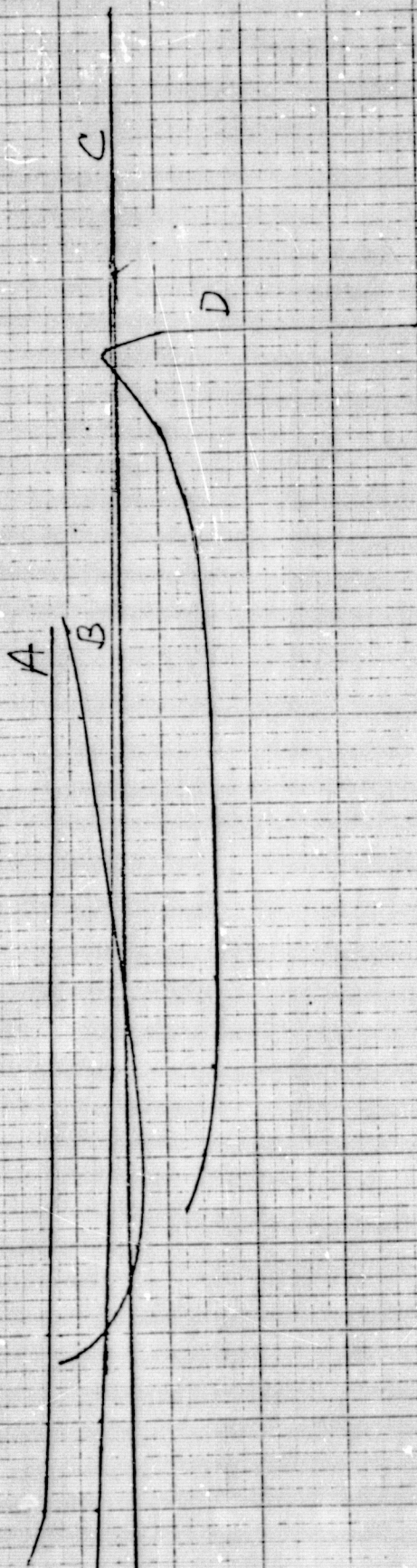
314

35

50

35

#70 Solithane 113



A - Room Temperature
 B - Room Temperature to 100°C
 C - Isothermal at 100°C
 D - Heat to Destruction

A (mins per cycle)	36	72	108	144	180	216	242	278	314	350
B (mins)	20	40	60	80	100	120	140	160	180	200
C (mins)	36	72	108	144	180	216	242	278	314	350
D (mins)	36	72	108	144	180	216	242	278	314	350

#11 KIV-600

ORIGINAL
OF POOR QUALITY

A - Room Temperature
B - Room Temperature to 100°C
C - Isothermal at 100°C

Time (mins)	Temp (°C)	Pressure (atm)	Volume (cc)
0	25	1.00	100
10	25	1.00	100
20	25	1.00	100
30	25	1.00	100
40	25	1.00	100
50	25	1.00	100
60	25	1.00	100
70	25	1.00	100
80	25	1.00	100
90	25	1.00	100
100	25	1.00	100
110	25	1.00	100
120	25	1.00	100
130	25	1.00	100
140	25	1.00	100
150	25	1.00	100
160	25	1.00	100
170	25	1.00	100
180	25	1.00	100
190	25	1.00	100
200	25	1.00	100
210	25	1.00	100
220	25	1.00	100
230	25	1.00	100
240	25	1.00	100
250	25	1.00	100
260	25	1.00	100
270	25	1.00	100
280	25	1.00	100
290	25	1.00	100
300	25	1.00	100
310	25	1.00	100
320	25	1.00	100
330	25	1.00	100
340	25	1.00	100
350	25	1.00	100
360	25	1.00	100
370	25	1.00	100
380	25	1.00	100
390	25	1.00	100
400	25	1.00	100
410	25	1.00	100
420	25	1.00	100
430	25	1.00	100
440	25	1.00	100
450	25	1.00	100
460	25	1.00	100
470	25	1.00	100
480	25	1.00	100
490	25	1.00	100
500	25	1.00	100
510	25	1.00	100
520	25	1.00	100
530	25	1.00	100
540	25	1.00	100
550	25	1.00	100
560	25	1.00	100
570	25	1.00	100
580	25	1.00	100
590	25	1.00	100
600	25	1.00	100
610	25	1.00	100
620	25	1.00	100
630	25	1.00	100
640	25	1.00	100
650	25	1.00	100
660	25	1.00	100
670	25	1.00	100
680	25	1.00	100
690	25	1.00	100
700	25	1.00	100
710	25	1.00	100
720	25	1.00	100
730	25	1.00	100
740	25	1.00	100
750	25	1.00	100
760	25	1.00	100
770	25	1.00	100
780	25	1.00	100
790	25	1.00	100
800	25	1.00	100
810	25	1.00	100
820	25	1.00	100
830	25	1.00	100
840	25	1.00	100
850	25	1.00	100
860	25	1.00	100
870	25	1.00	100
880	25	1.00	100
890	25	1.00	100
900	25	1.00	100
910	25	1.00	100
920	25	1.00	100
930	25	1.00	100
940	25	1.00	100
950	25	1.00	100
960	25	1.00	100
970	25	1.00	100
980	25	1.00	100
990	25	1.00	100
1000	25	1.00	100
1010	25	1.00	100
1020	25	1.00	100
1030	25	1.00	100
1040	25	1.00	100
1050	25	1.00	100
1060	25	1.00	100
1070	25	1.00	100
1080	25	1.00	100
1090	25	1.00	100
1100	25	1.00	100
1110	25	1.00	100
1120	25	1.00	100
1130	25	1.00	100
1140	25	1.00	100
1150	25	1.00	100
1160	25	1.00	100
1170	25	1.00	100
1180	25	1.00	100
1190	25	1.00	100
1200	25	1.00	100
1210	25	1.00	100
1220	25	1.00	100
1230	25	1.00	100
1240	25	1.00	100
1250	25	1.00	100
1260	25	1.00	100
1270	25	1.00	100
1280	25	1.00	100
1290	25	1.00	100
1300	25	1.00	100
1310	25	1.00	100
1320	25	1.00	100
1330	25	1.00	100
1340	25	1.00	100
1350	25	1.00	100
1360	25	1.00	100
1370	25	1.00	100
1380	25	1.00	100
1390	25	1.00	100
1400	25	1.00	100
1410	25	1.00	100
1420	25	1.00	100
1430	25	1.00	100
1440	25	1.00	100
1450	25	1.00	100
1460	25	1.00	100
1470	25	1.00	100
1480	25	1.00	100
1490	25	1.00	100
1500	25	1.00	100
1510	25	1.00	100
1520	25	1.00	100
1530	25	1.00	100
1540	25	1.00	100
1550	25	1.00	100
1560	25	1.00	100
1570	25	1.00	100
1580	25	1.00	100
1590	25	1.00	100
1600	25	1.00	100
1610	25	1.00	100
1620	25	1.00	100
1630	25	1.00	100
1640	25	1.00	100
1650	25	1.00	100
1660	25	1.00	100
1670	25	1.00	100
1680	25	1.00	100
1690	25	1.00	100
1700	25	1.00	100
1710	25	1.00	100
1720	25	1.00	100
1730	25	1.00	100
1740	25	1.00	100
1750	25	1.00	100
1760	25	1.00	100
1770	25	1.00	100
1780	25	1.00	100
1790	25	1.00	100
1800	25	1.00	100
1810	25	1.00	100
1820	25	1.00	100
1830	25	1.00	100
1840	25	1.00	100
1850	25	1.00	100
1860	25	1.00	100
1870	25	1.00	100
1880	25	1.00	100
1890	25	1.00	100
1900	25	1.00	100
1910	25	1.00	100
1920	25	1.00	100
1930	25	1.00	100
1940	25	1.00	100
1950	25	1.00	100
1960	25	1.00	100
1970	25	1.00	100
1980	25	1.00	100
1990	25	1.00	100
2000	25	1.00	100

#72

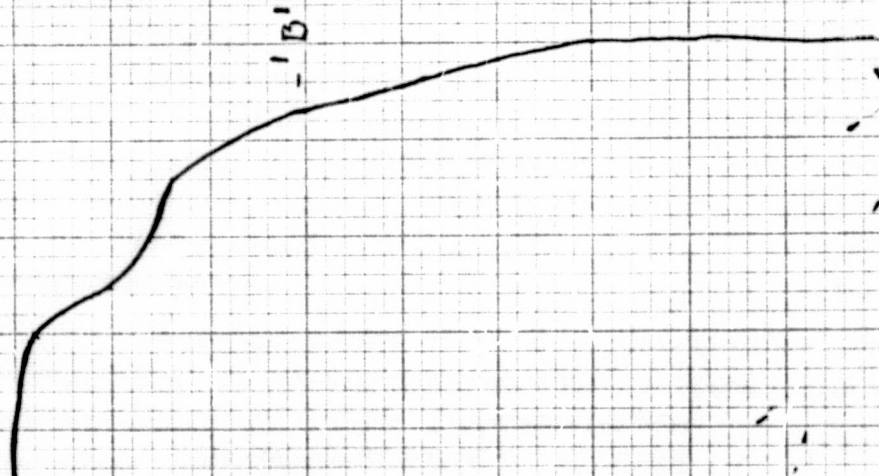
SAMPLE UNTREATED N₂102

'A'

'A' 45°C Isotherm

'B' HEAT RUN
(50°C TO DESTRUCTION)

'B'



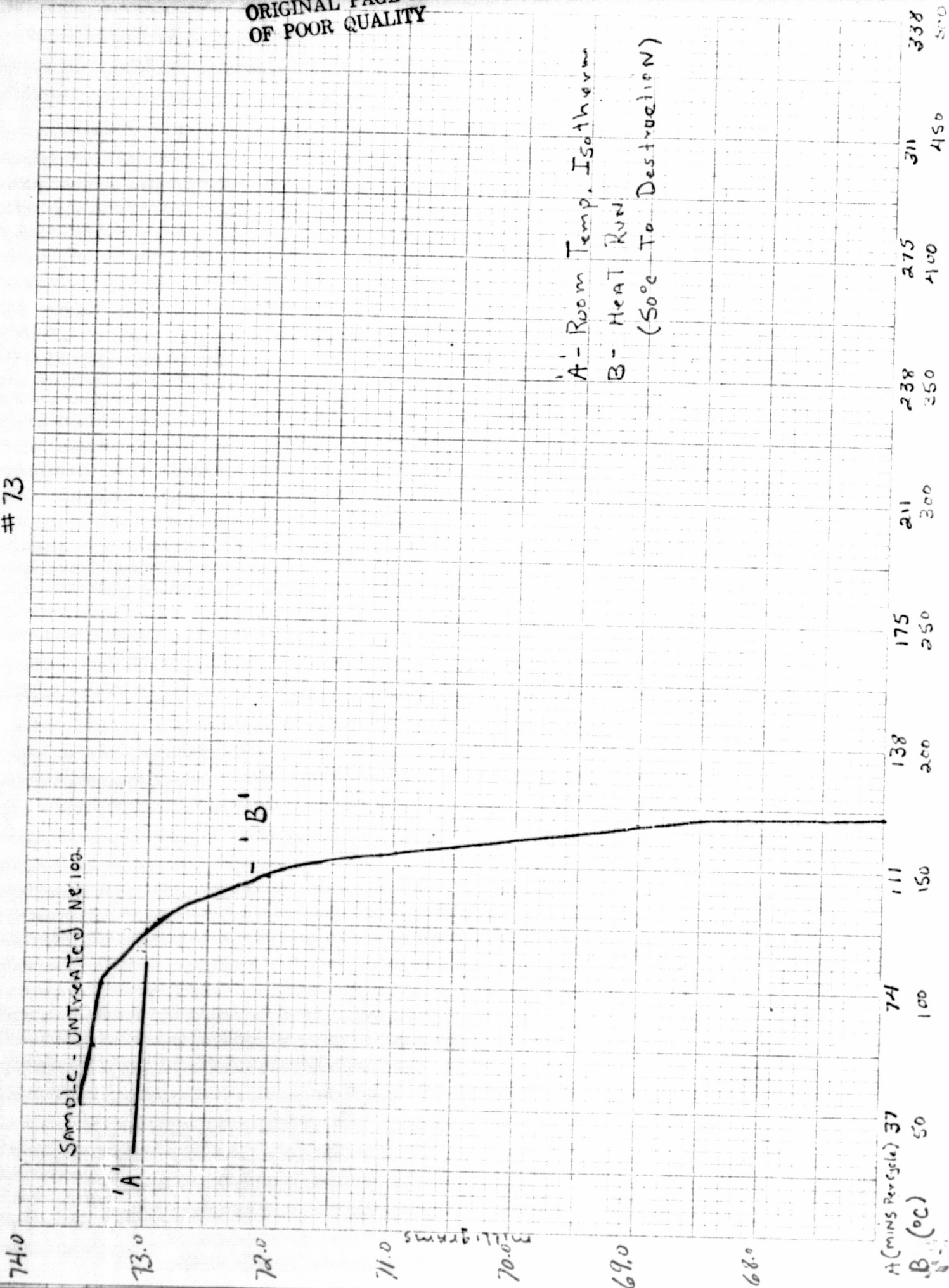
A (mins per cycle)	B (°C)	Weight (mg)
50	50	73.5
100	74	74.5
150	111	73.5
200	138	72.5
250	175	73.5
300	211	74.5
350	238	74.5
400	275	74.5
450	311	74.5
500	338	74.5

10 Square to the Inch

73

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A - Room Temp. Isotherm
B - Heat Run
(50°C To Destruction)



67.

66.0

65.0

64.0

63.0

62.

61.0

SAMPLE - UNTREATED NE 102

'A'

'A' Room Temp Isotherm

A mins
per
cycle

37

74

111

137

175

211

238

275

311

338

#75

SAMPLE- UNTreated 102

'A' 45°C To IsoTherm

ORIGINAL
OF POOR QUALITY

99.4

99.2

99.0

98.8

98.6
MILLIGRAMS

98.4

98.2

98.0

ALMINS per 37
cycle

741

111

138

175

211

238

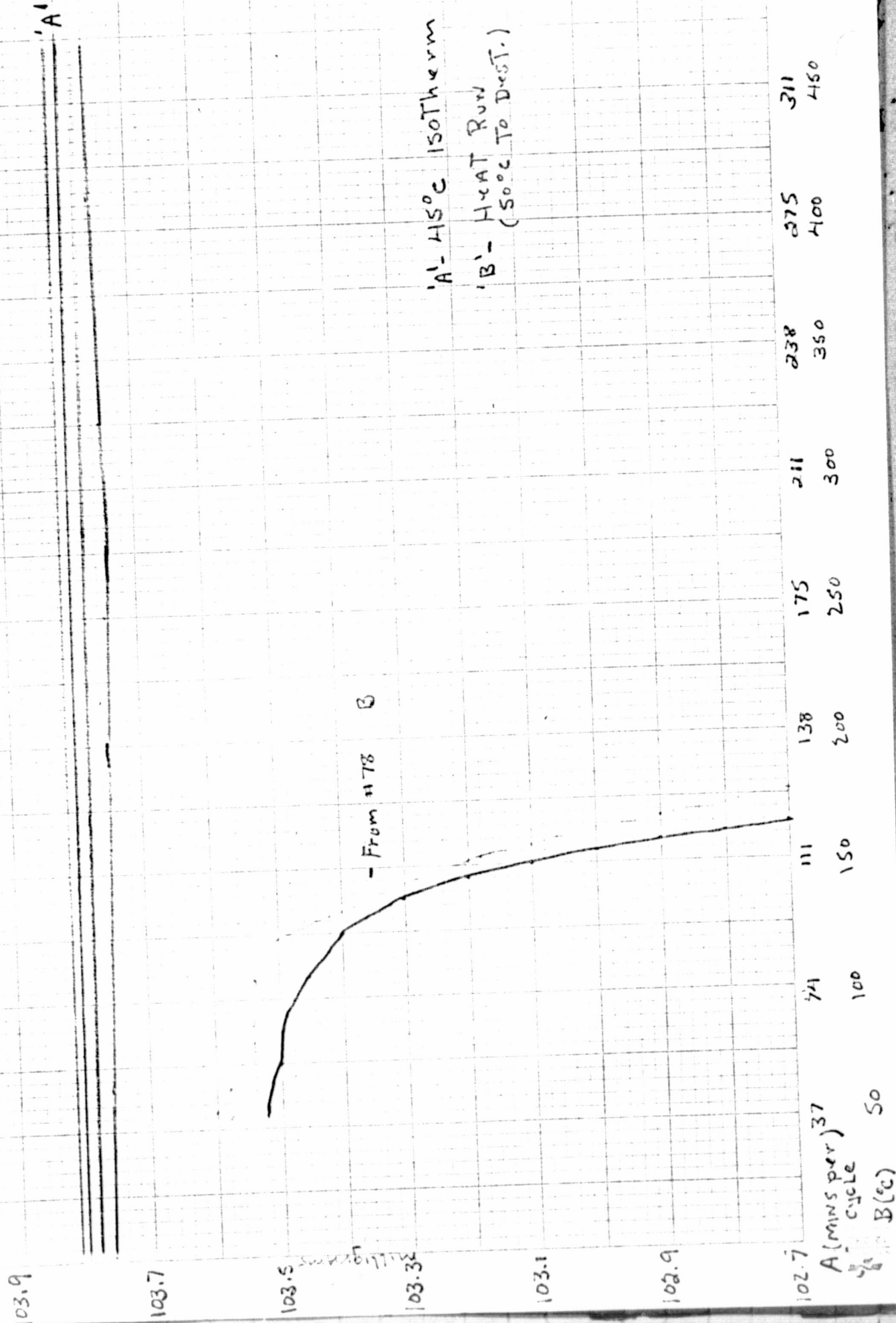
275

311

338

#76

SAMPLE - BAKED NE 102

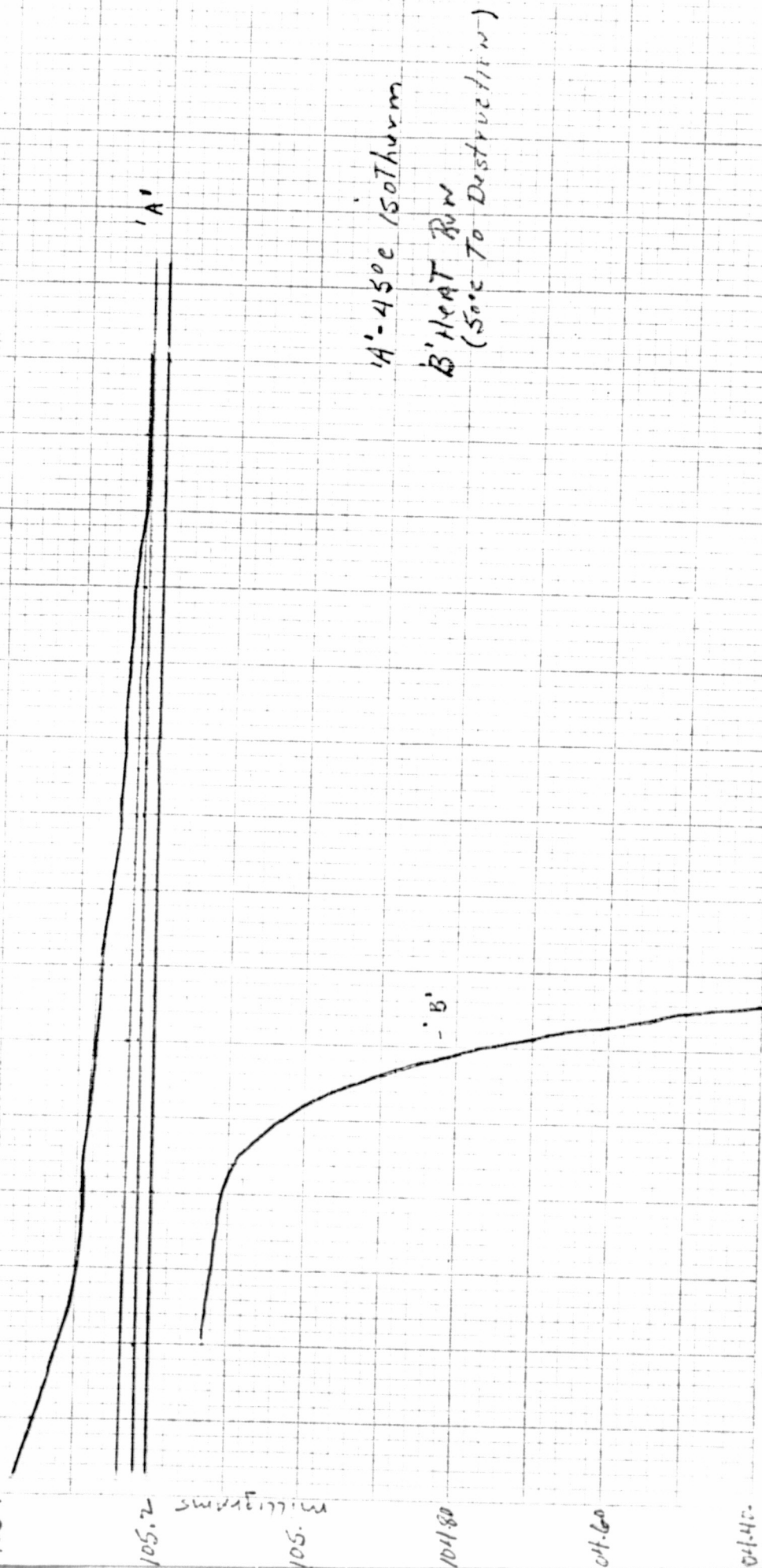


F79

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SAMPLE - Untreated Me 102

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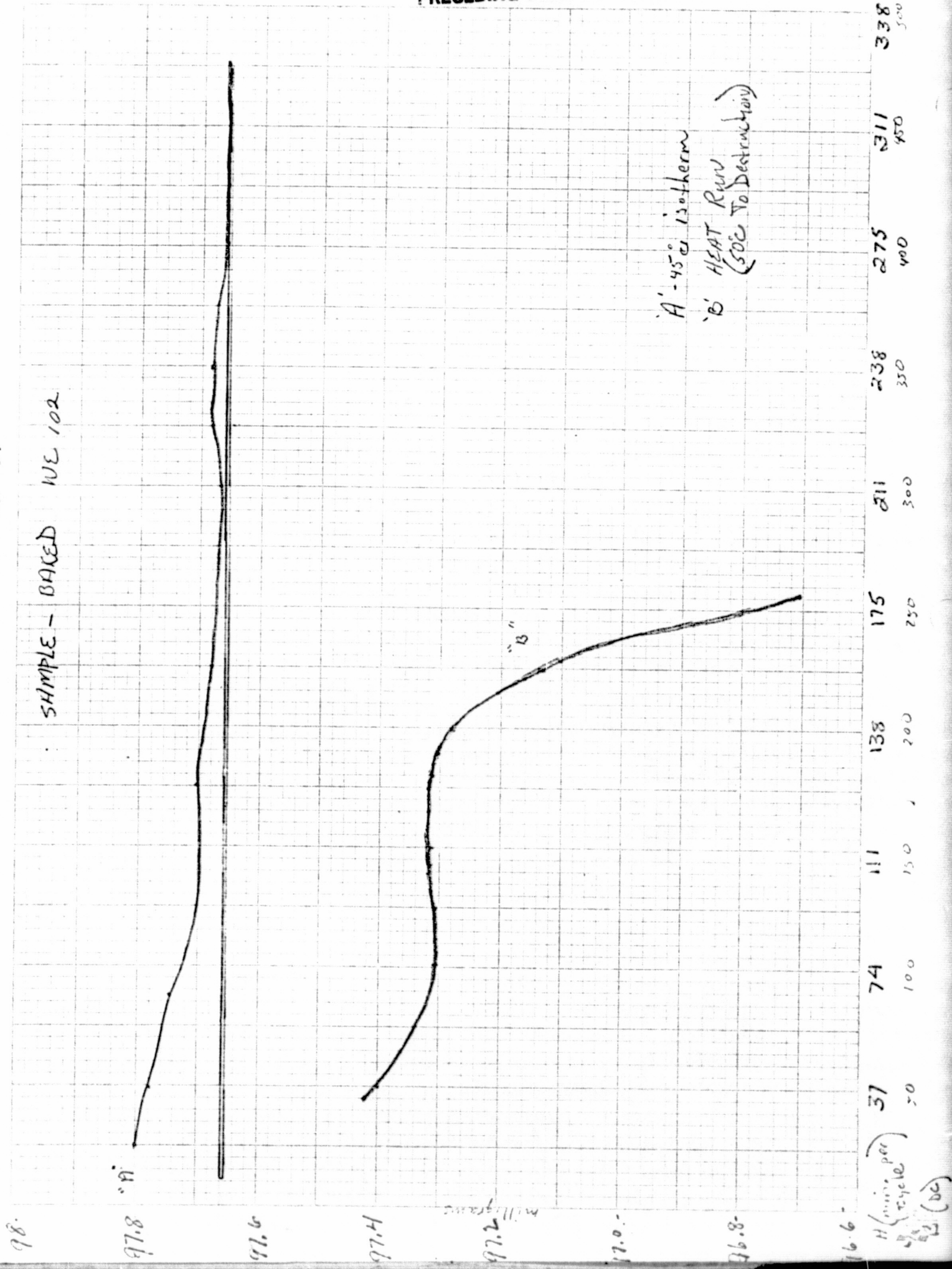


A' - 450c Isotherm
B' Heat Run
(50c to Destruction)

10 Square to the Inch

#81

SAMPLE - BAGED WE 102



#82-

SAMPLE UNTREATED 110

'B' HEAT RUN
(50°C TO Destruction)

103.6

103.41

103.2

103.006

Mill. gms

102.80

102.60

102.40

102.23

A (mins per
cycle)

37

74

111

138

175

211

238

275

311

338

50

100

150

200

250

300

350

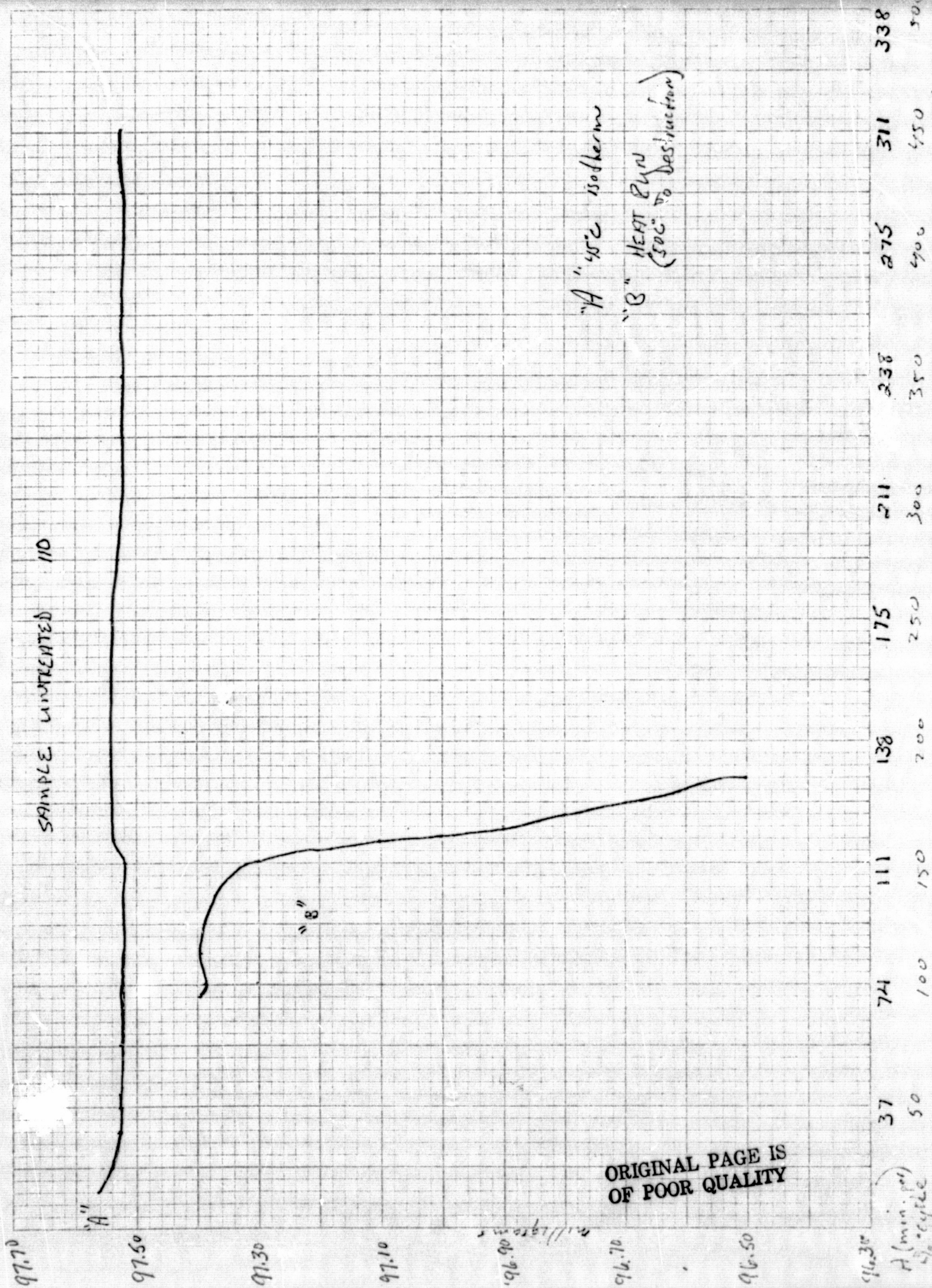
400

450

500

B (°C)

83



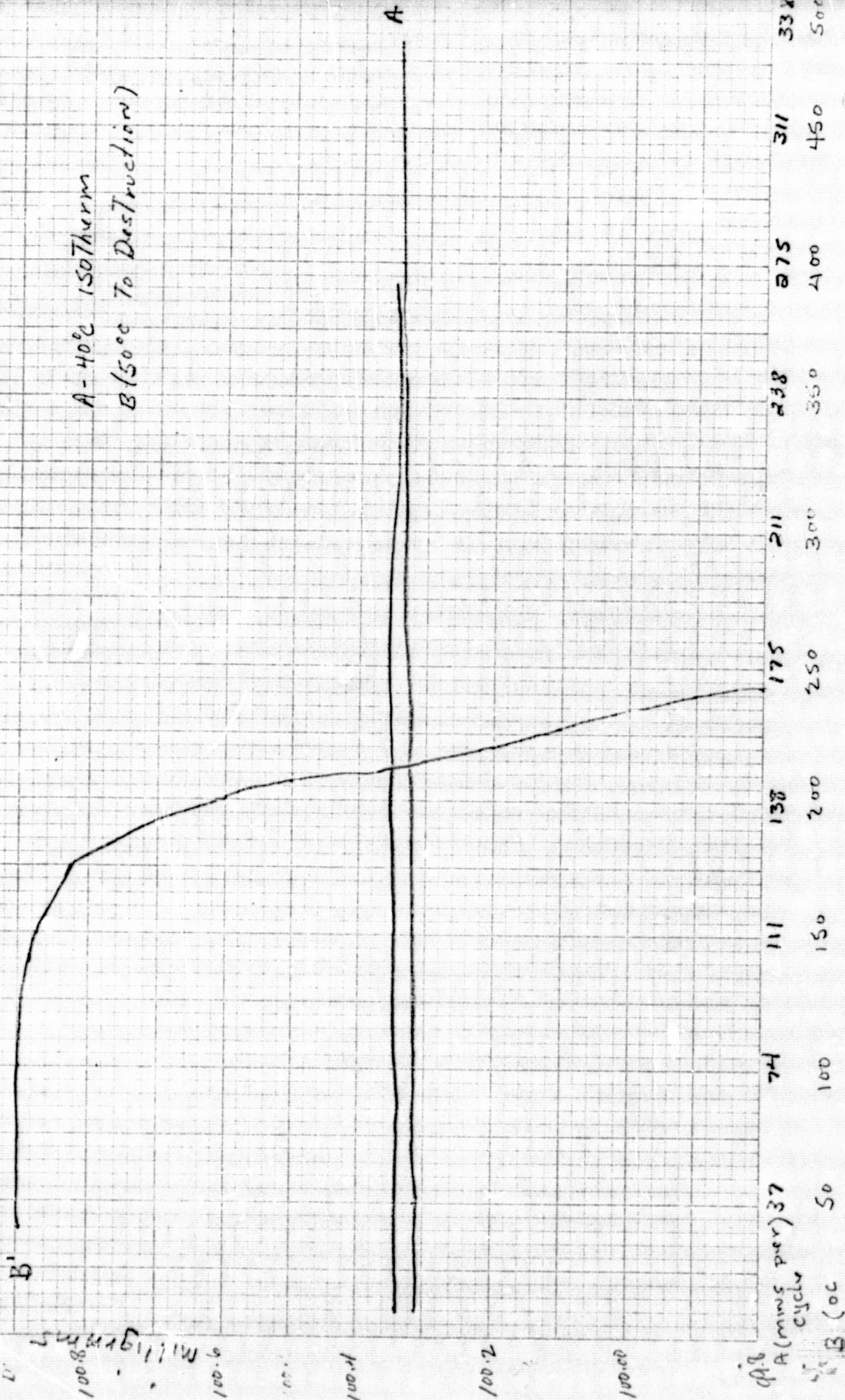
ORIGINAL PAGE IS
OF POOR QUALITY

Handwritten notes at the bottom right corner, including 'A (mon. pol)' and 'B (sample)'.

84

Sample - 1018 Tape

A - 40°C Isotherm
B (50°C To Destruction)

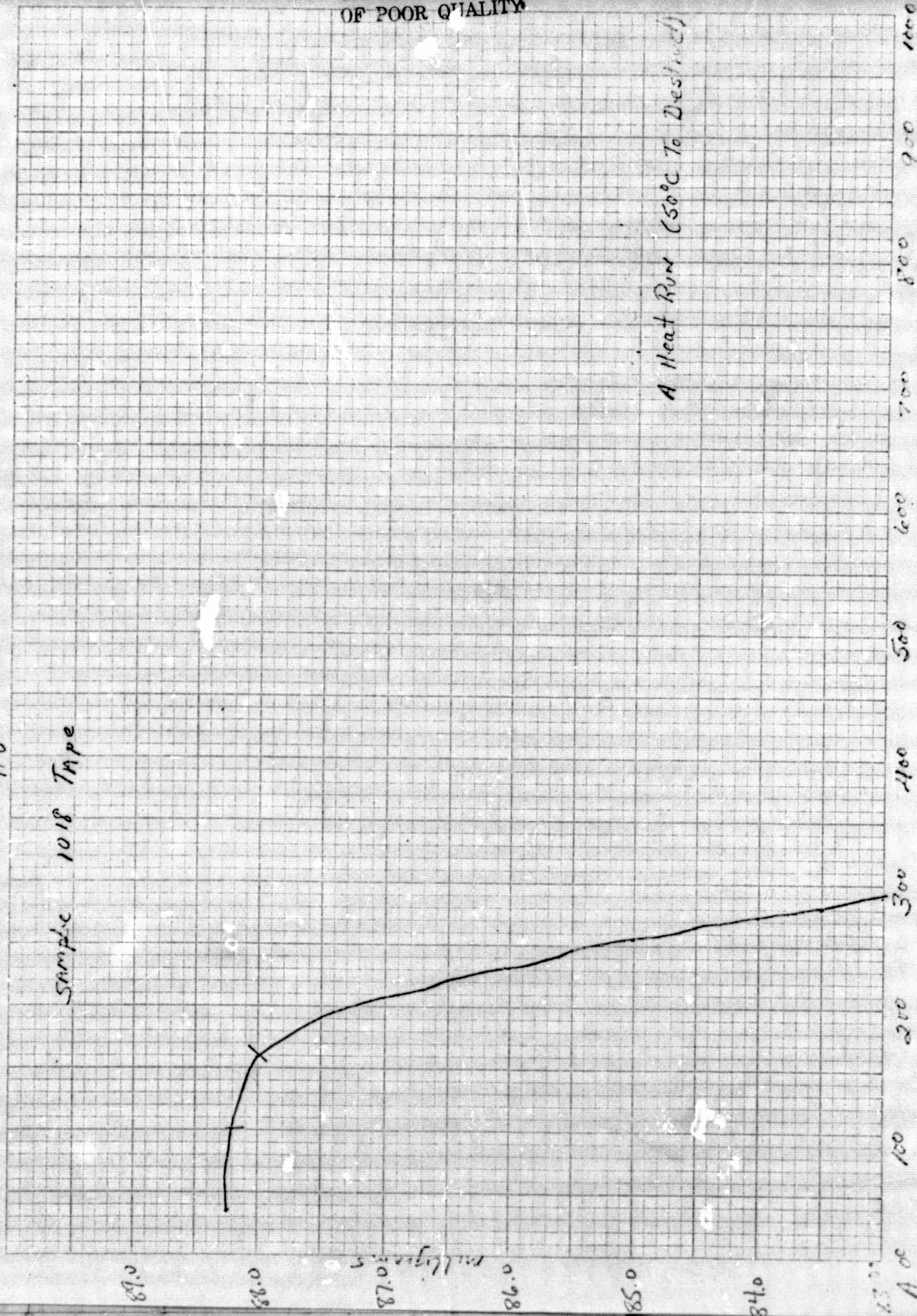


4.8
A (min per cycle)
B (oc)

7188

Sample 1018 Type

A Heat Run (50°C To Destroyed)



89

SAMPLE UNTREATED 0080 TARE

101

100

99

98

milligrams

97

96

95

94
A(00)

100

200

300

400

500

600

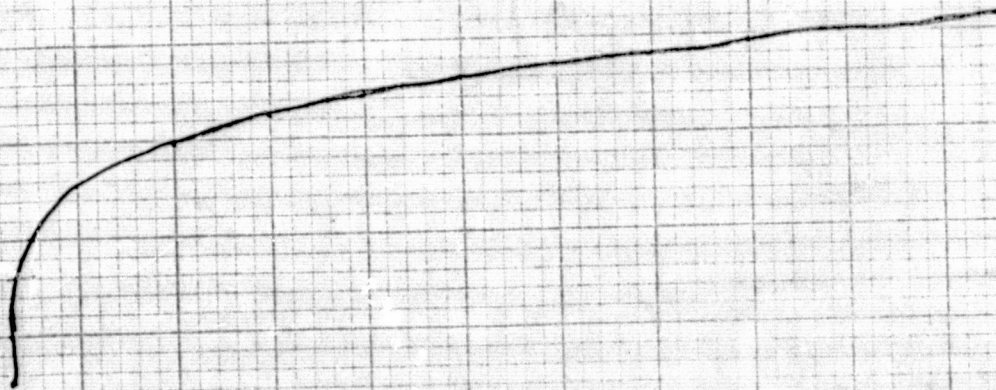
700

800

900

1000

"H" Run to destruction



#= 90

SAMPLE UNDEGRADED 0080 YAPE

101

100

99

98

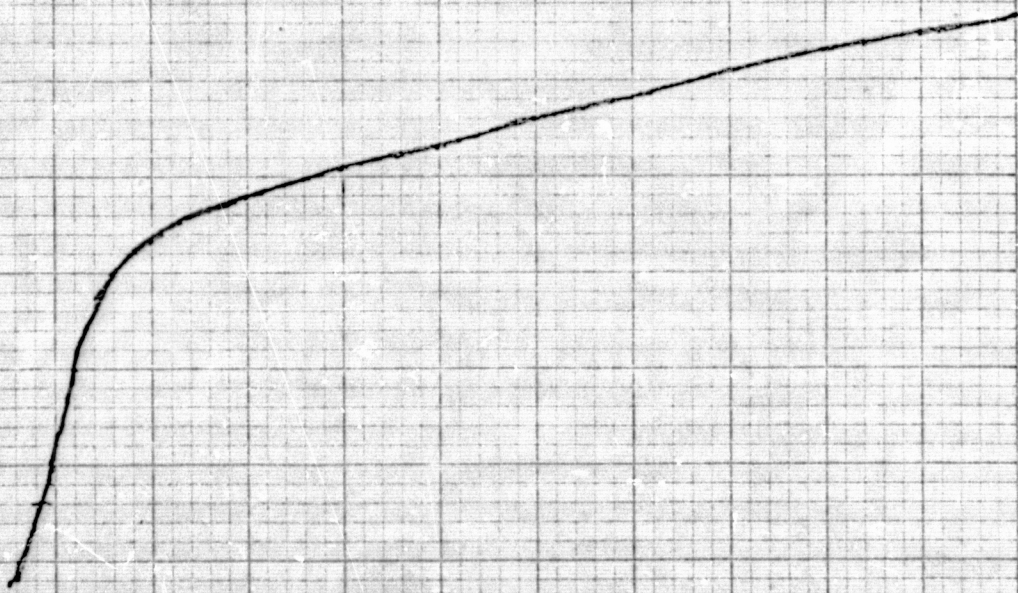
97

96

95

94

Milligrams



"H" Run to destruction

94
95
96
97
98
99
100
101

100

200

300

400

500

600

700

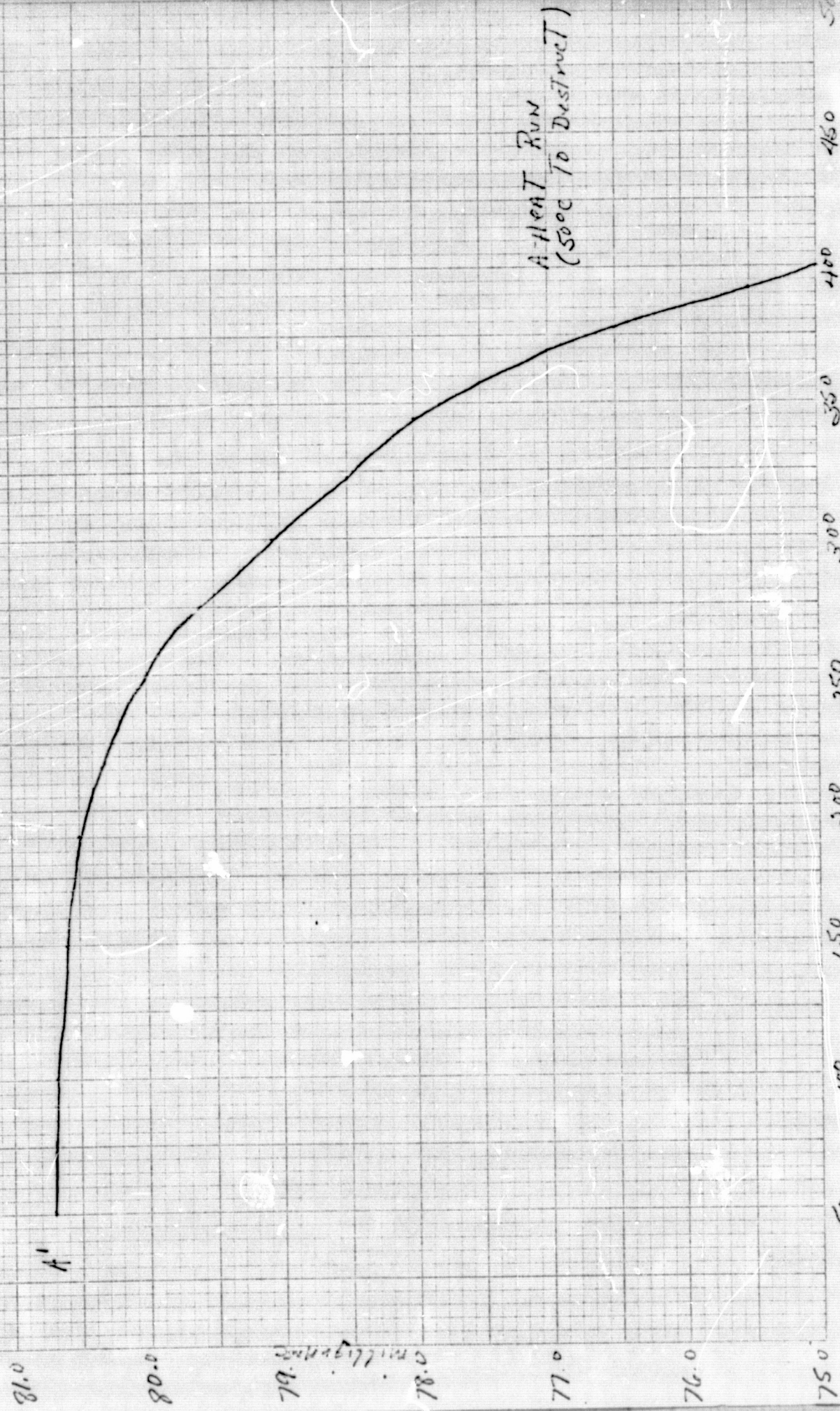
800

900

1000

#191

SAMPLE 1018 Taps



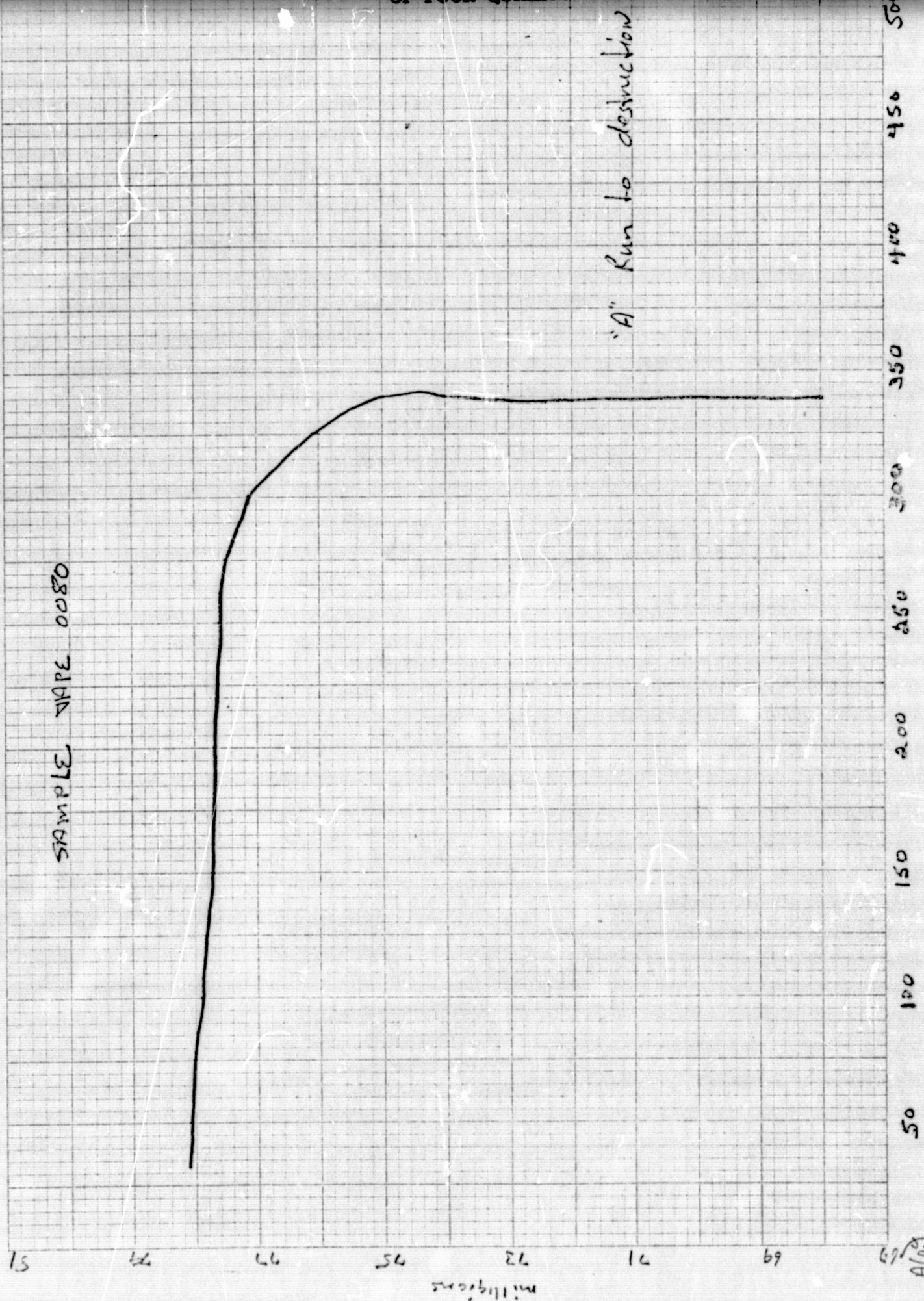
A-HEAT RUN
(5000 To Destruct)

milligram bl

11.6

#-92

SAMPLE WAVE 0080



"A" Run to destruction

94

SAMPLE TAPE 0080

"A" Run to destruction

96.00

93.00

88.00

84.00

Milligrams

80.00

76.00

72.00

68.00

64.00

100

200

300

400

500

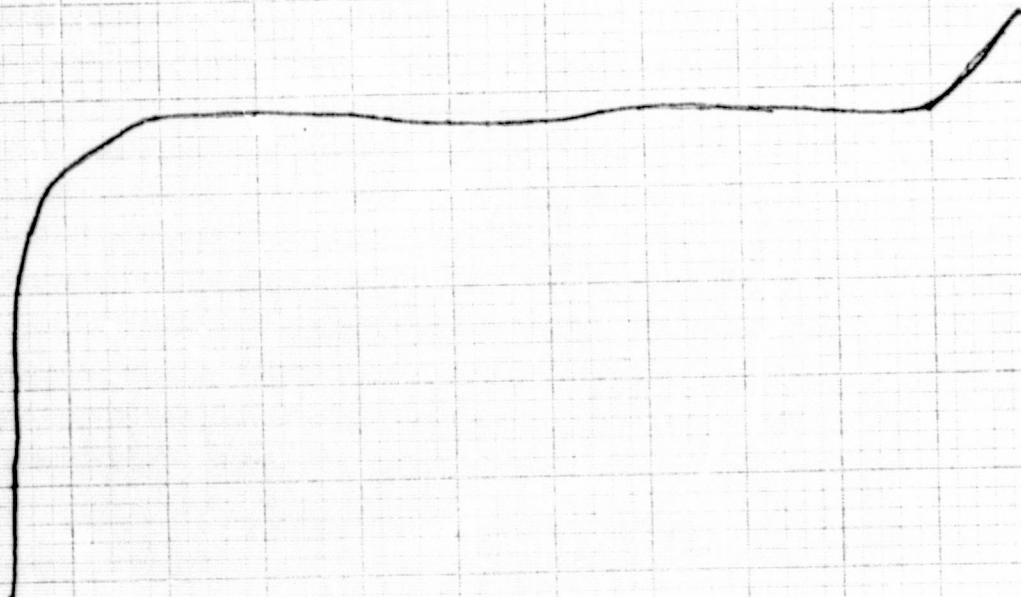
600

700

800

900

1000



#95

SAMPLE- 1018 TAPE

92

91

90
milligrams

89

88

87

86

AOC

A-Heat Run
(500°C To Destruction)

100

200

300

400

500

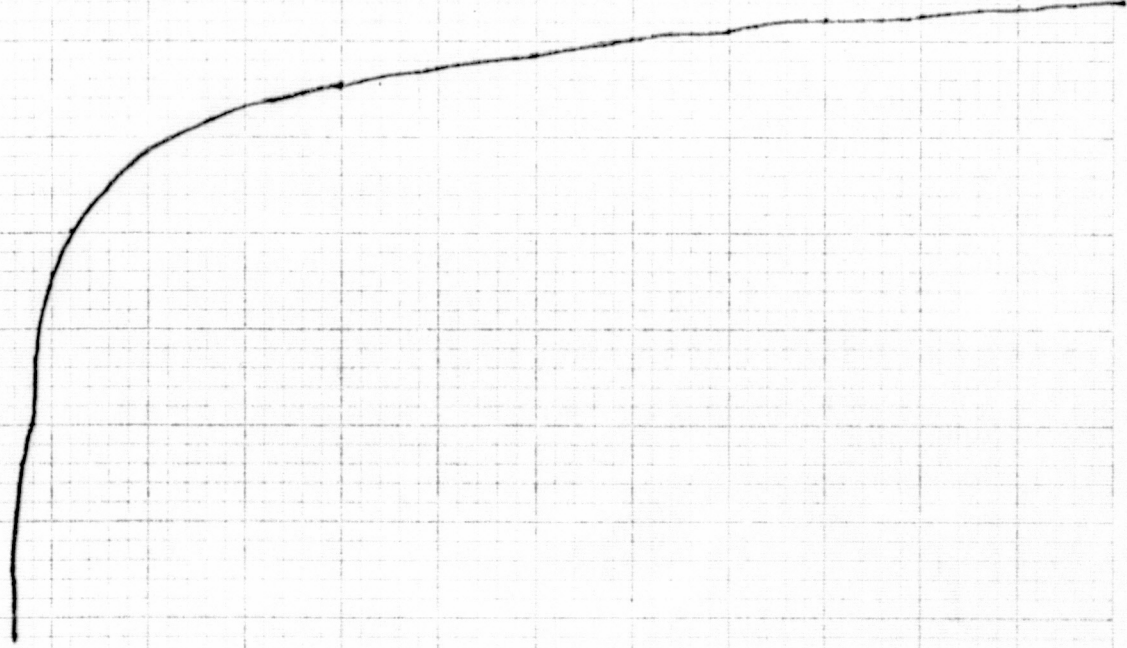
600

700

800

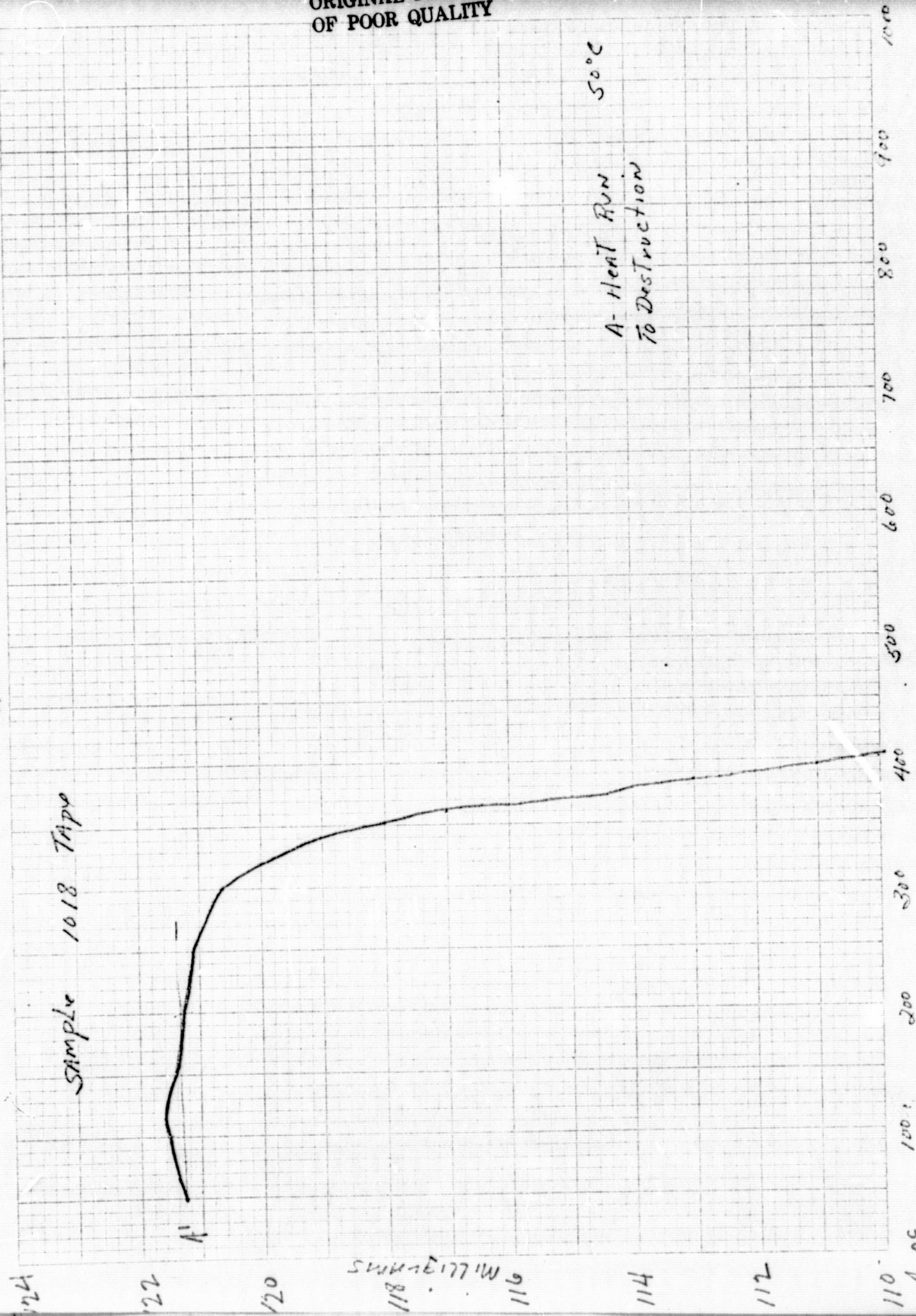
900

1000



#96

Sample 1018 Tape



SWH-1577W
118
116
114
112
110

A 0c

#97

Sample - 1618 Tape

A-Heat Run
(50°C to Destruction)

115

113

111

109
milligrams

107

105

103

101

A.OC

100

200

300

400

500

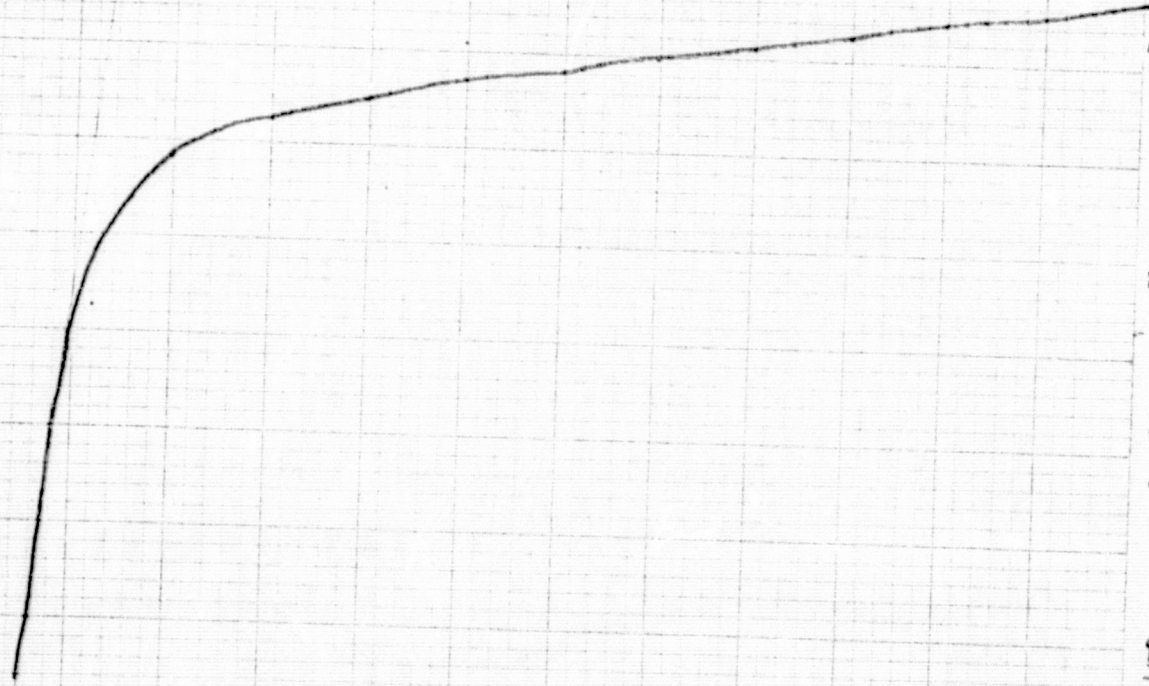
600

700

800

900

100



#98

SAMPLE 1018 TAP

A

milligrams
100

A. Heat Rod
500°C To Destruction

101
A. 0

100

200

300

400

500

600

700

800

900

1000

66 # 99

SAMPLE - 0080TAP

118

114

110

106
milligram

102

98

94

90

A. C.

100

200

300

400

500

600

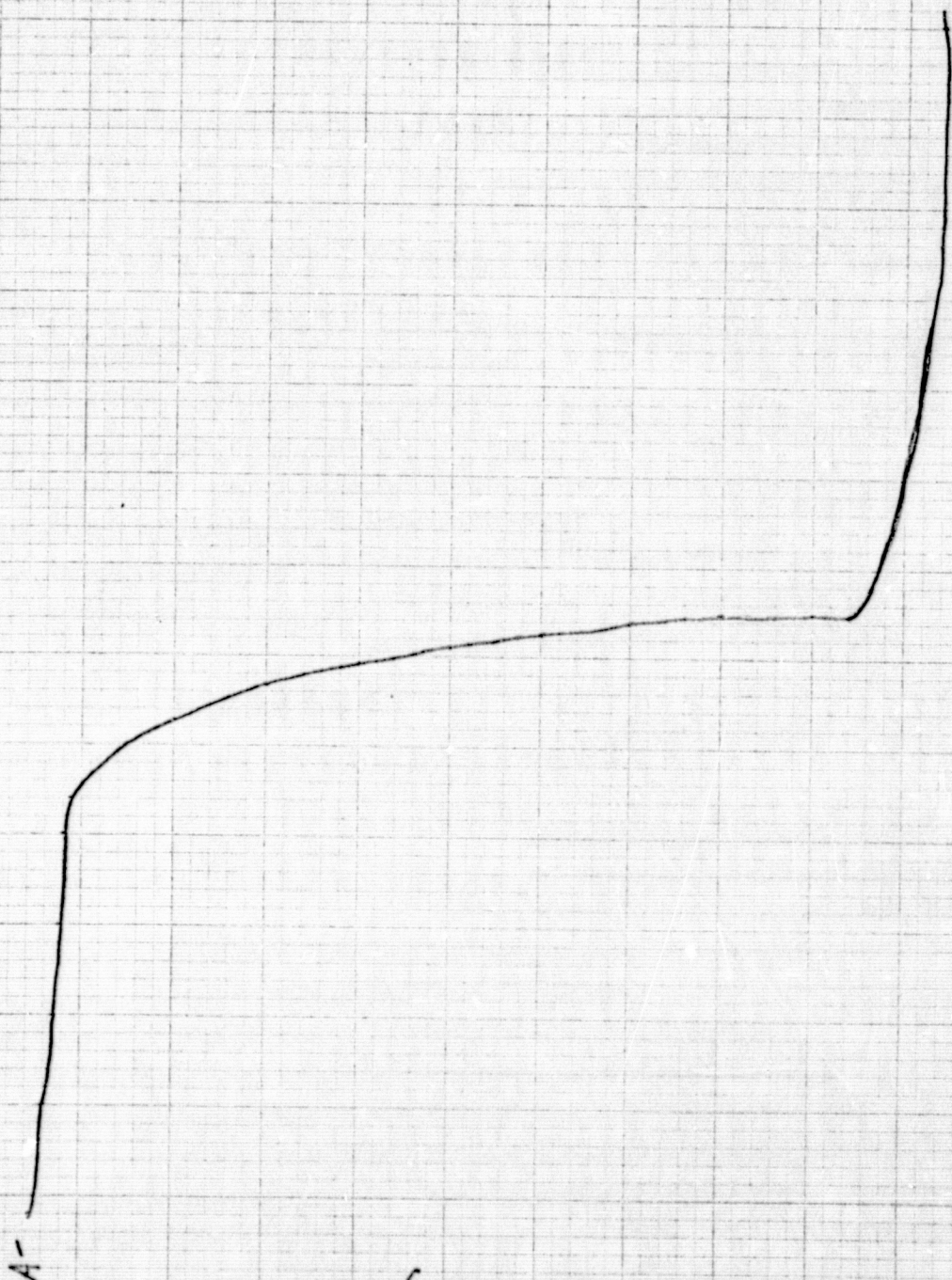
700

800

900

1000

A-HEAT RUN
500°C TO DESTRUCTION



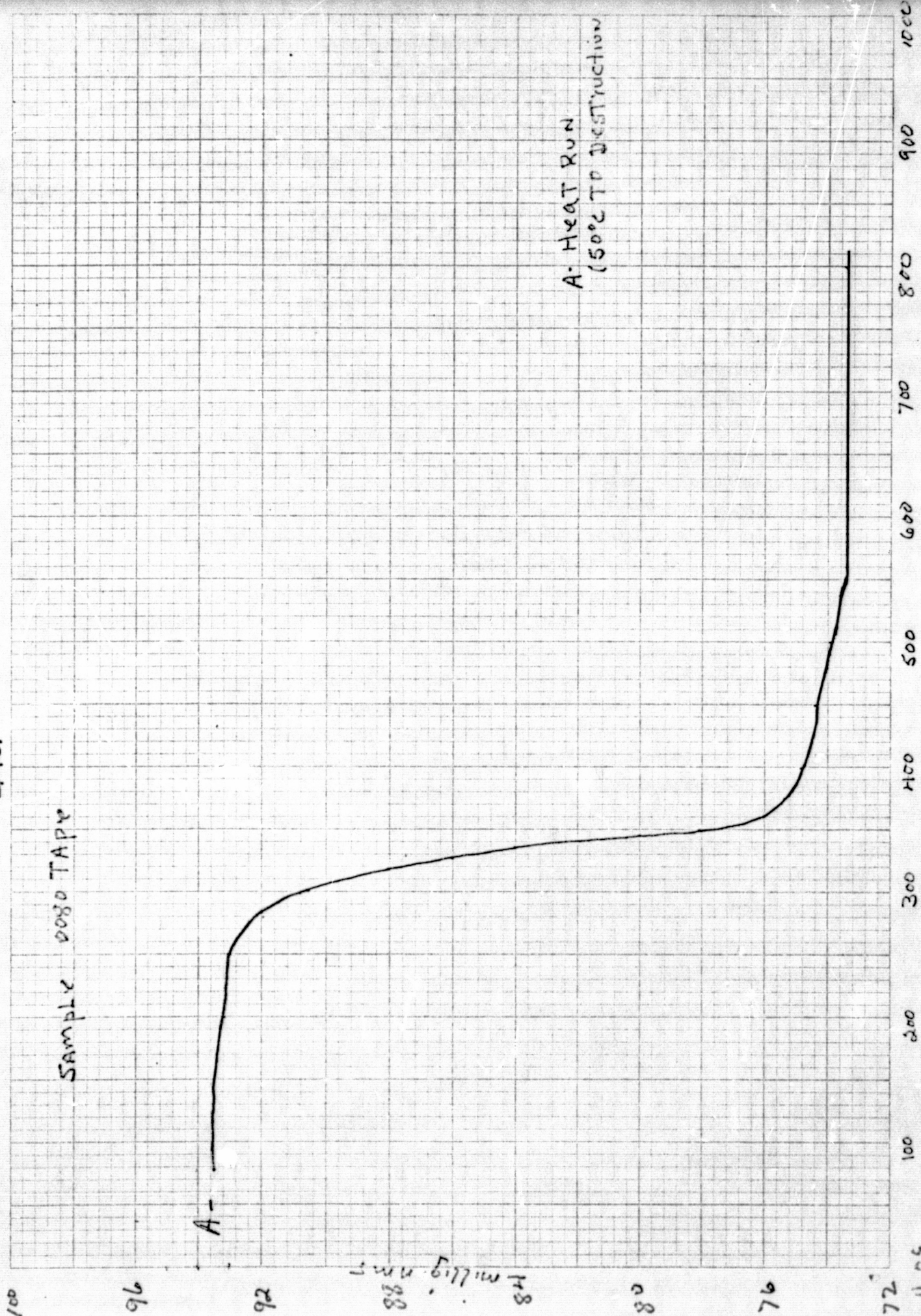
101

SAMPLE 0080 TAPE

A-

88
milling
81

A- HEAT RUN
(50% TO DESTRUCTION)



#102

Sample - 10080 TAPA

67

63

59

milligrams

55

51

47

43

A°C

A-

A-HEAT RUN
500C TO DESTRUCTION

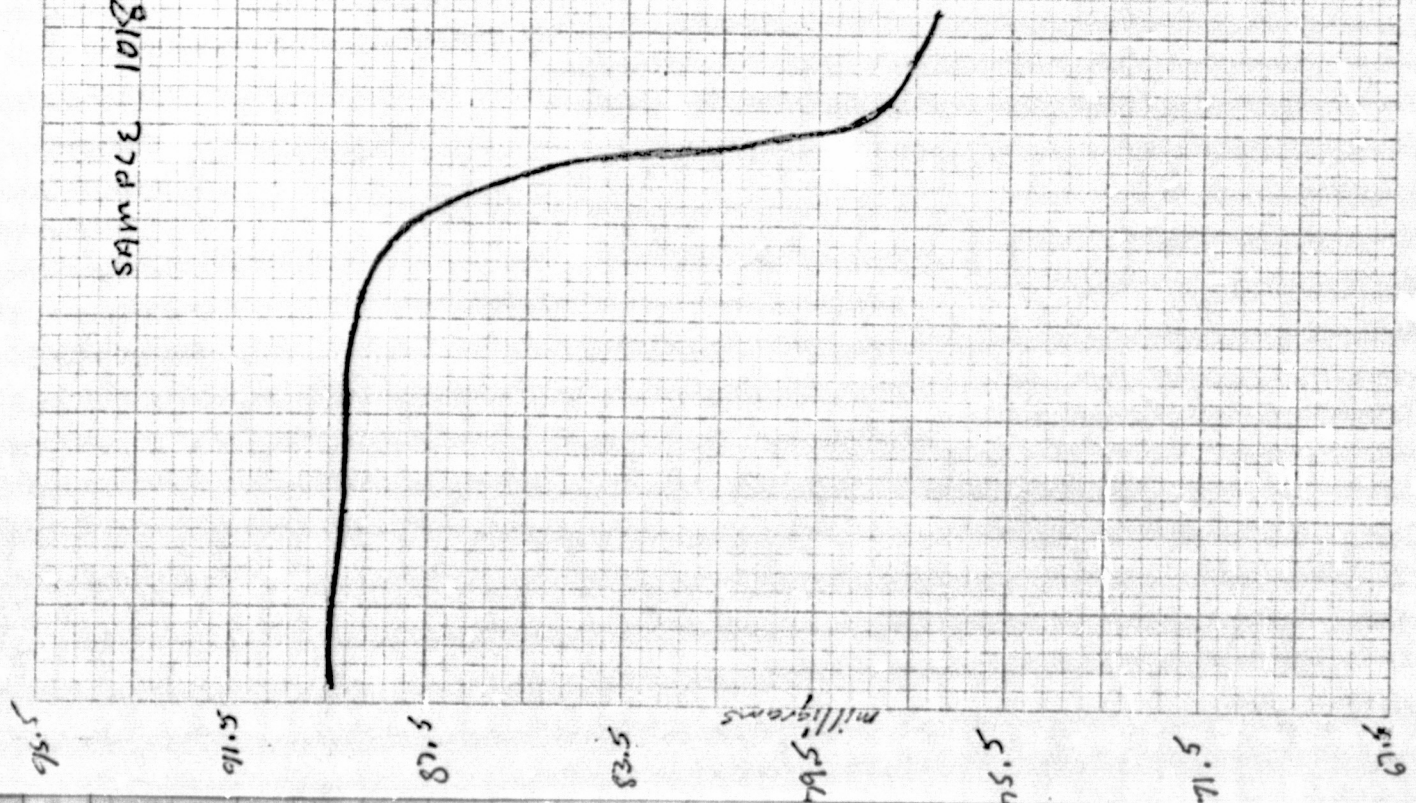
100 200 300 400 500 600 700 800 900 100

OF POOR QUALITY

#-103

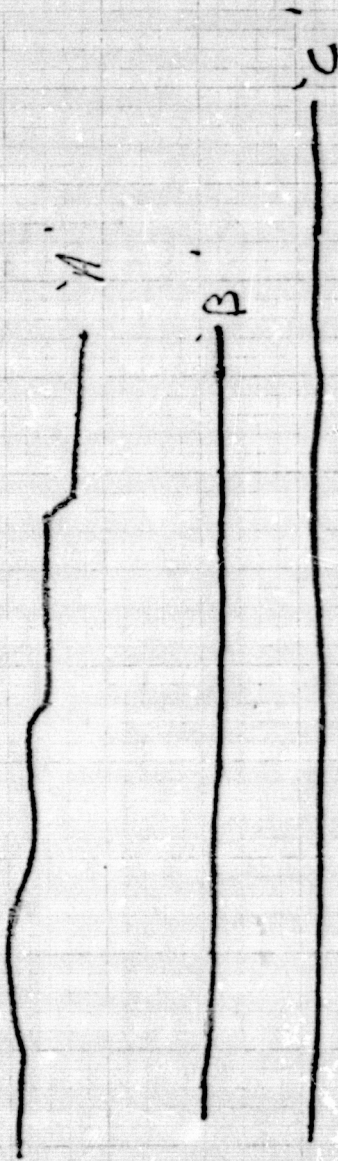
SAMPLE 1018 TAPE

Heat run
(50°C to Destruction)



#106

SAMPLE. Black graphite cloth



A' isothermal 105°
 B' rerun of above
 C' 150 @ 1050c

5000
 4 (20 min)
 2 (per cell)
 1 (per cell)

20 40 60 80 100 120 140 160 180 200

107

Sample Adhesive (Epoxy)

A - Room Temp Run



42.5 41.5 40.5 39.5 38.5 37.5 36.5

50 100 150 200 250 300 350 400 450 500

107 A

SAMPLE - BLACK Graphite Cloth



- D @ 100°C Per in

- A - Room Temp.
- B - Room Temp TO 105°C
- C - 150 @ 105°C
- D - Heat to Destruction

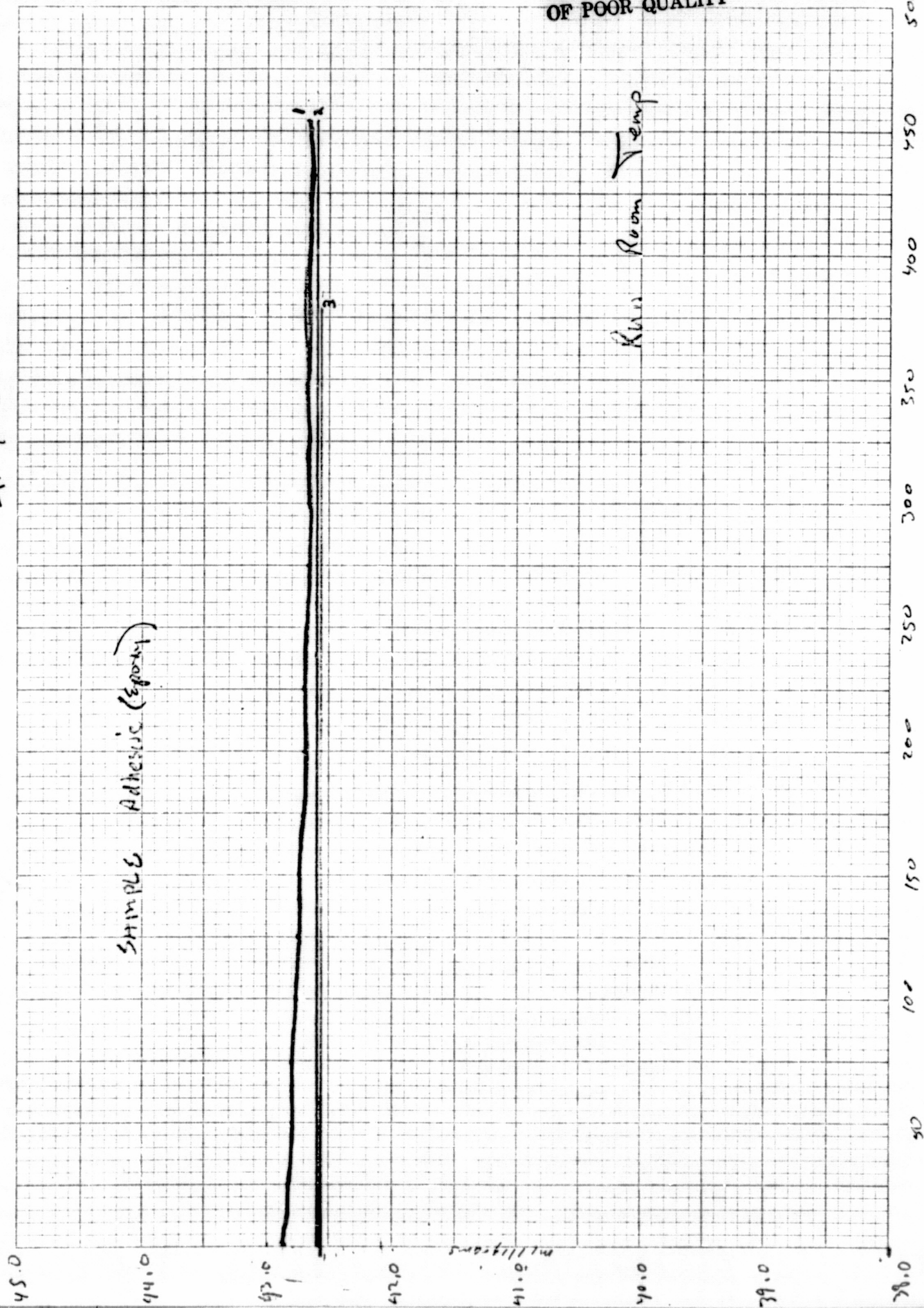
Time (min)	Weight (g)	Temp (°C)	Notes
0	1.0	Room	A
10	0.5	Room	B
20	0.2	Room	C
0	0.2	Room	D
10	0.5	100	D
20	0.2	100	D
30	0.2	100	D
40	0.2	100	D
50	0.2	100	D
60	0.2	100	D
70	0.2	100	D
80	0.2	100	D
90	0.2	100	D
100	0.2	100	D
110	0.2	100	D
120	0.2	100	D
130	0.2	100	D
140	0.2	100	D
150	0.2	100	D
160	0.2	100	D
170	0.2	100	D
180	0.2	100	D
190	0.2	100	D
200	0.2	100	D
210	0.2	100	D
220	0.2	100	D
230	0.2	100	D
240	0.2	100	D
250	0.2	100	D
260	0.2	100	D
270	0.2	100	D
280	0.2	100	D
290	0.2	100	D
300	0.2	100	D
310	0.2	100	D
320	0.2	100	D
330	0.2	100	D
340	0.2	100	D
350	0.2	100	D
360	0.2	100	D
370	0.2	100	D
380	0.2	100	D
390	0.2	100	D
400	0.2	100	D
410	0.2	100	D
420	0.2	100	D
430	0.2	100	D
440	0.2	100	D
450	0.2	100	D
460	0.2	100	D
470	0.2	100	D
480	0.2	100	D
490	0.2	100	D
500	0.2	100	D

#108

SAMPLE Adhesive (epoxy)

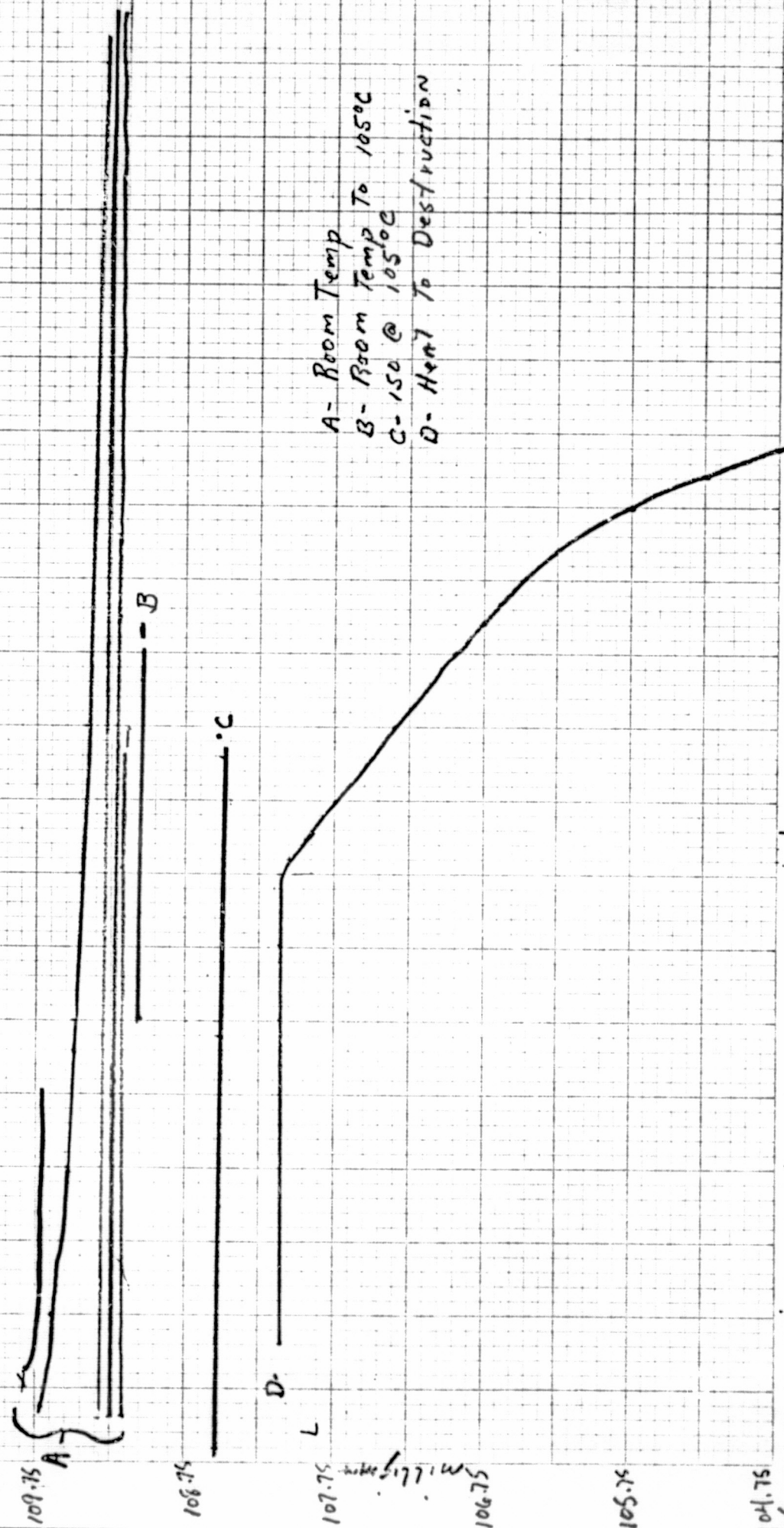
Room Temp

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111.75

Sample- Epoxy Adh.



A- Room Temp
B- Room Temp To 105°C
C- 150 @ 105°C
D- Heat To Destruction

AFMIMS per cycle/37	74	111	138	175	211	238	275	311	338
B ₁ OC	40	60	80	100	120	140	160	180	200
C(mpc)	74	111	138	175	211	238	275	311	338
					200	350	400	450	500

110

RTU 560/9811

" Room Temp Run "

37 74 111 138 175 211 238 275 311 338

102.9

82.9

162.9

142.9

22.9

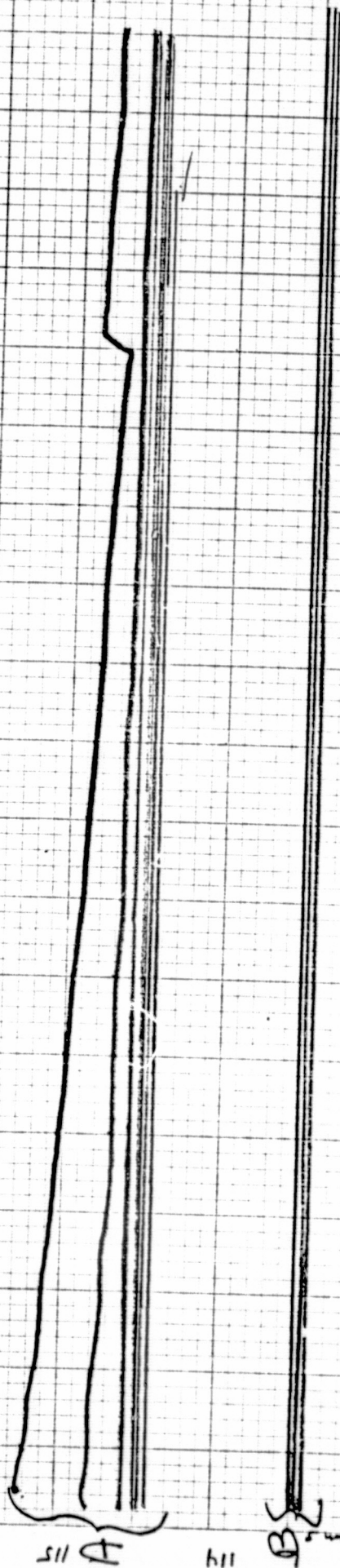
102.9

82.9

62.9

#111

RTV 560-78.1



A' Room Temp
B' also, at 125"

A (m-111)
B (m-111)

112

RTU - 560-9811

-A' Room Temp Run

37 74 111 138 175 211 236 275 311 338

1003
1003
1003

112.3

116.3

115.3

114.3

113.3

milligram

112.3

111.3

DIFFERENTIAL THERMAL ANALYSIS (DTA)

Differential thermal analyses are conducted with a DuPont Model 900 DTA unit. Two tubes, one containing sample and the other a reference material, such as glass beads, are heated at a uniform rate in a heating block. The sample and the reference material will initially be at the same temperature. The temperature differential will remain zero as the two are heated unless the sample undergoes an endothermic or exothermic reaction. The DTA unit plots the temperature of the heating block on the x-axis. On the y-axis it plots the difference in temperature between the sample and reference, ΔT . An exotherm is plotted as a rise from the base line, an endotherm as a decrease from the base line.

Comparison of graphs 18 and 19 shows that a large part of the apparent slow endotherm on C-19 alone is due to an instrumental thermocouple imbalance. In samples of C-19 with excess 40% KOH this imbalance is masked by the high specific heat of the solution.

Several silicone rubbers were analyzed by DTA, these being NASA Goddard #AF-E-332 silicone, S-383-70 silicone, and E-515-80(1). The temperature range was from -125°C to 25°C . The samples, plus the heating block which they were in, were cooled in liquid nitrogen and then warmed to room temperature at a programmed rate.

CONCLUSIONS

C-19 does not undergo either an endothermic or an exothermic reaction at temperatures below 100°C . It does not react alone, nor with excess 40% KOH, nor with excess Ag_2O in 40% KOH.

CONTINUATION

Additional runs are being made with other separator materials of interest to NASA.

EXPERIMENTAL PROCEDURE

Sample C-19, a cellophane separator used in batteries was tested. The separator has been impregnated with Ag_2O and is used in a KOH electrolyte.

Glass beads are used as the reference. Runs were made of 40% KOH solution against glass beads to determine any endotherms caused by evaporation of water.

Runs were made of glass beads vs. glass beads to detect any slope in the base line caused by thermocouple imbalance.

DISCUSSION OF RESULTS

The C-19 in 40% KOH showed no reaction below 115°C . Between 115°C and 120°C there is a sharp endotherm. If the sample is cooled and reheated the endotherm does not occur. The same results are found for C-19 plus Ag_2O in 40% KOH (see graphs 10-1 and 11).

The C-19 alone showed a much less sharp endotherm starting at about 90°C . (See graphs 13, 15). A sample of C-19 stored over "Drierite" showed a similar diffuse endotherm with a less rapid drop between 90° and 110°C (See graph 14, 17).

The samples of silicone rubber, graphs #60, 61, 62, showed no phase changes in the range -125°C to 25°C . On the initial samples a phase change for condensed water was shown at about 0°C . The latter sample tubes (#60, 61, 62) were closed and showed no ice to water phase change. (See graphs 60, 61, 62)

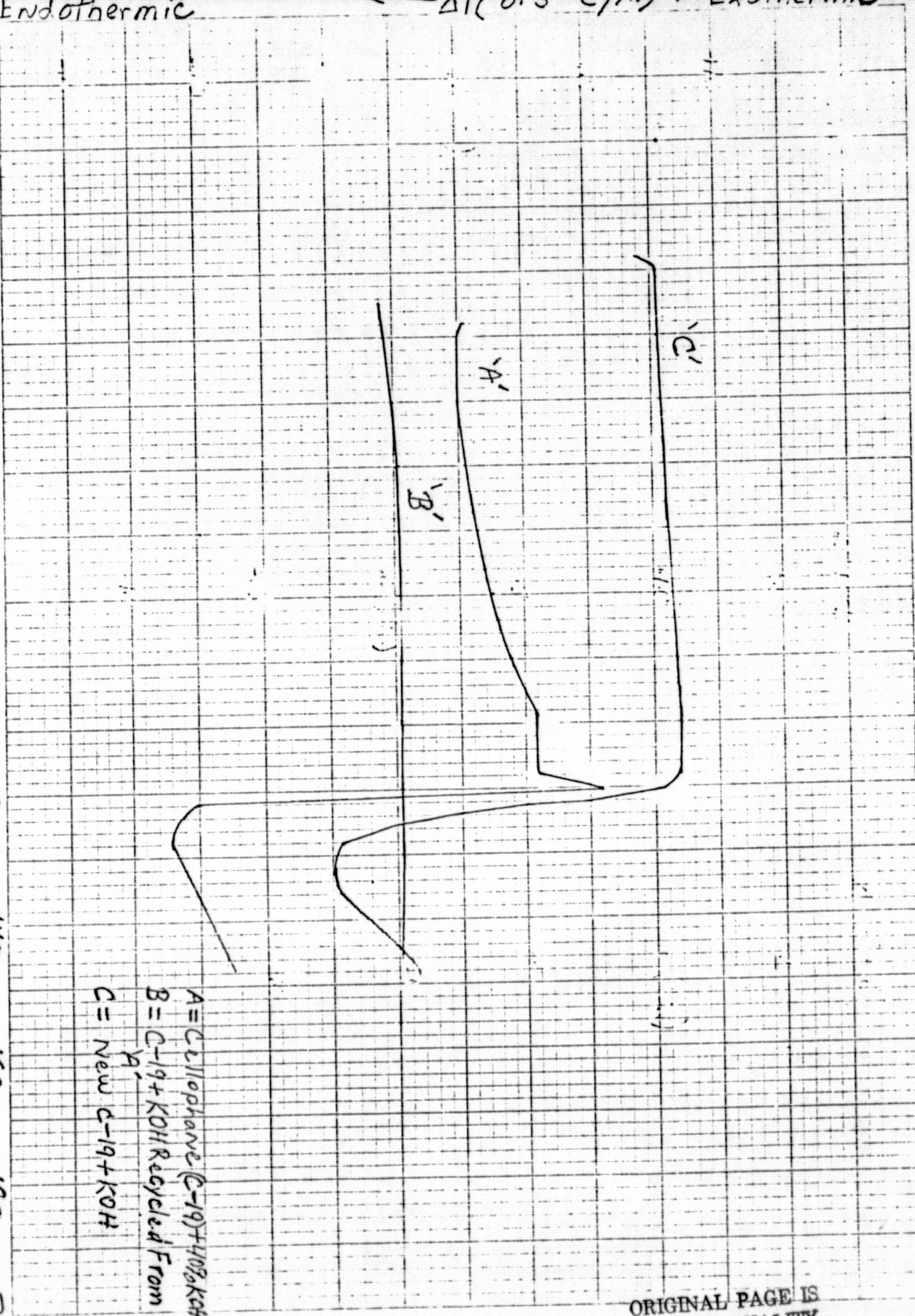
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#10A C-19 + 40% KOH

← $\Delta T (0.5^\circ \text{C/in})$ → Exothermic

Endothermic

Temp °C



A = Cellophane (C-19) + 40% KOH
 B = C-19 + KOH Recycled From A
 C = New C-19 + KOH

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106 C-19 + 40% KOH vs Glass beads

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Exothermic

ΔT

Endothermic

Temp °C

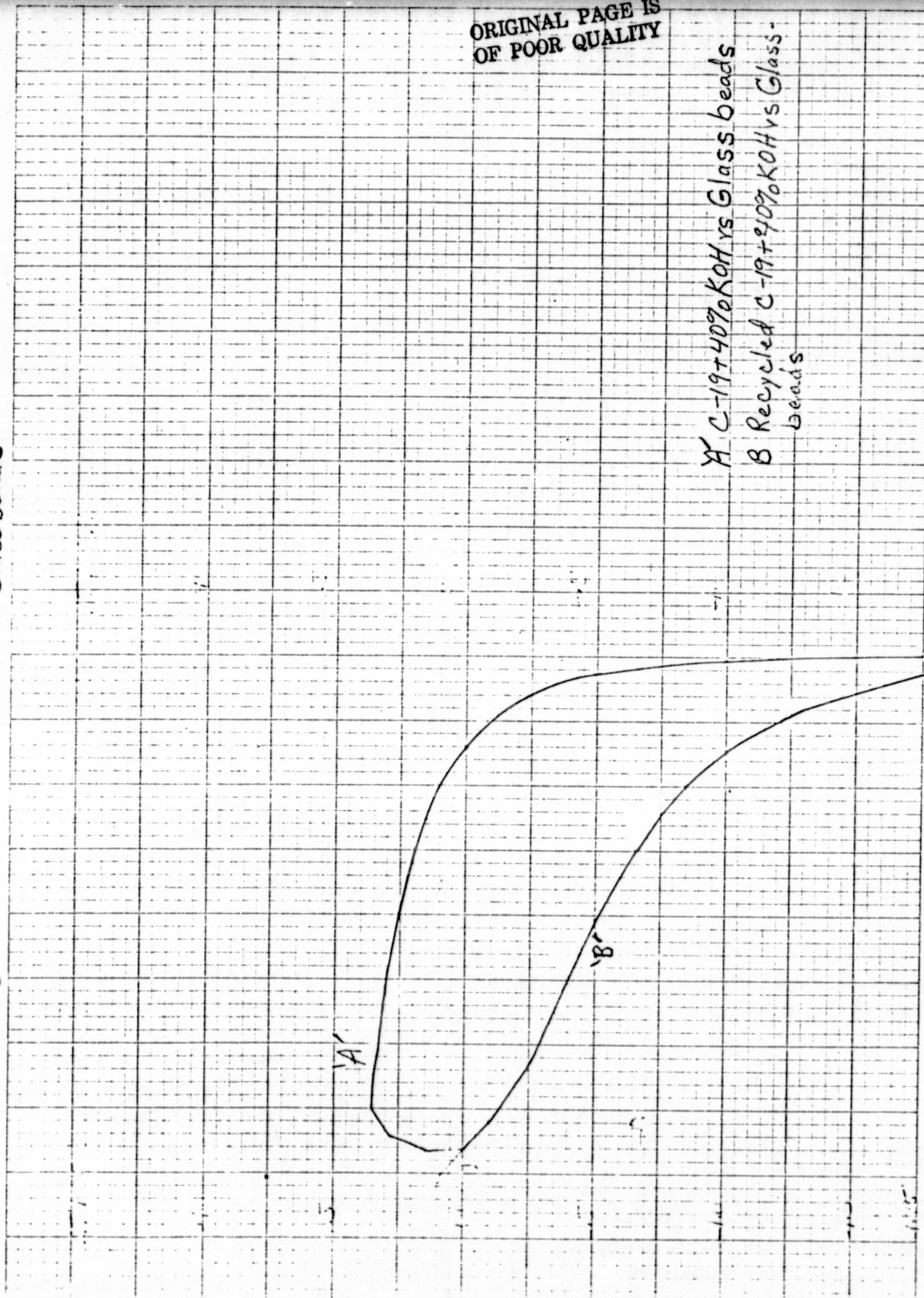
Temp °C

A'

B'

A C-19 + 40% KOH vs Glass beads
B Recycled C-19 + 40% KOH vs Glass beads

20 40 60 80 100 120 140 160 180 200

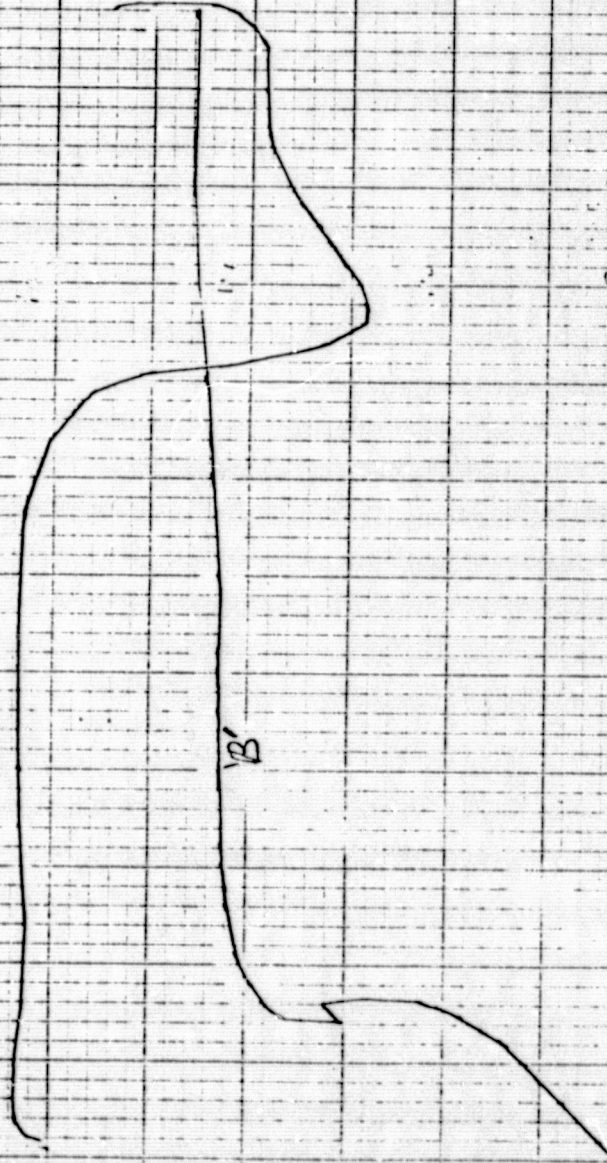


#11 Cellophane (C-19) + 40% KOH + 1/2 O₂

Endothermic → ΔT (0.5°C/min) → Exothermic

A

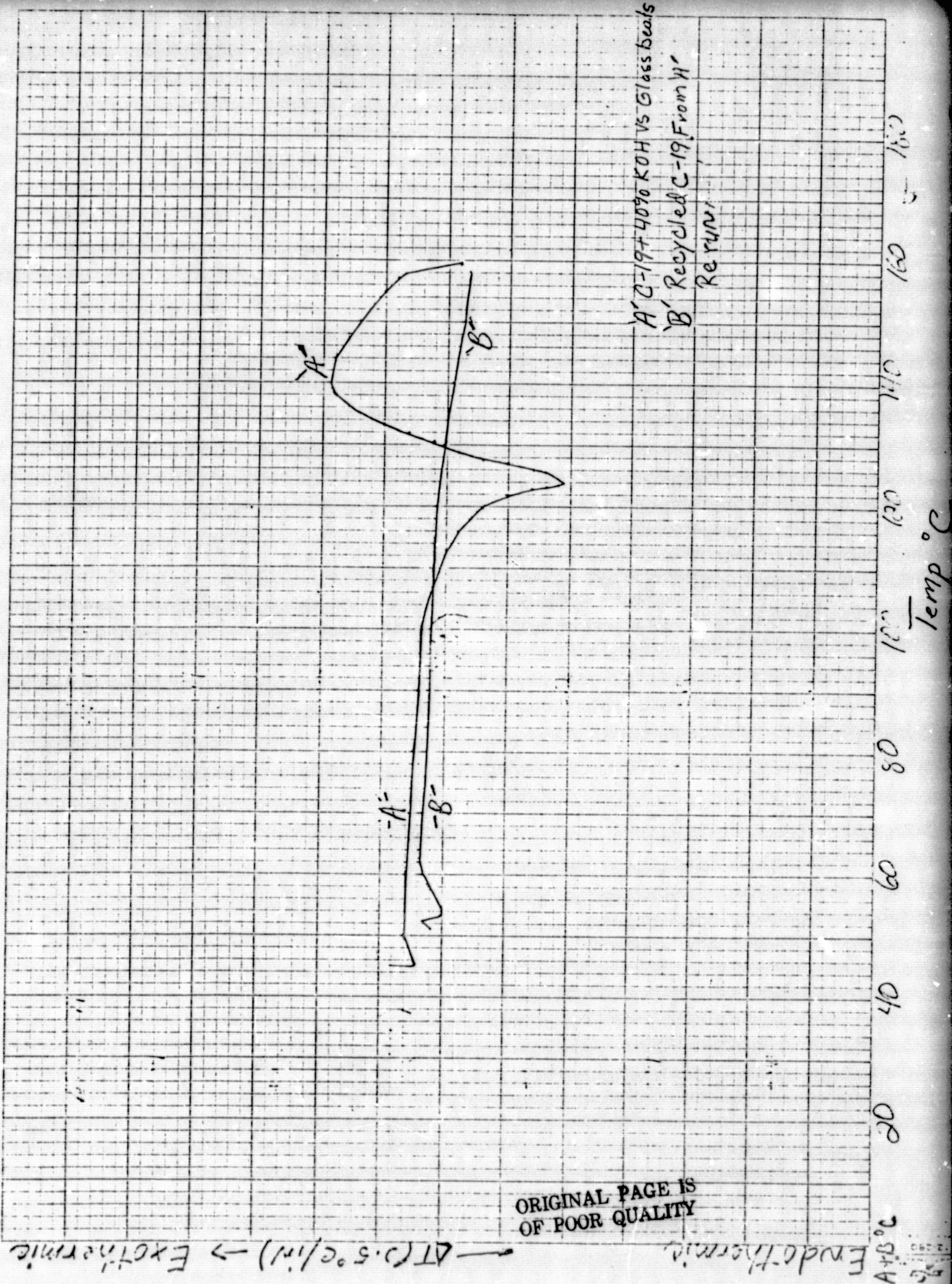
B



A' = C-19 + 40% KOH + Ag₂O
B' = C-19 From A' (Recycled)

Temp °C 40 60 80 100 120 140 160 180 200 220

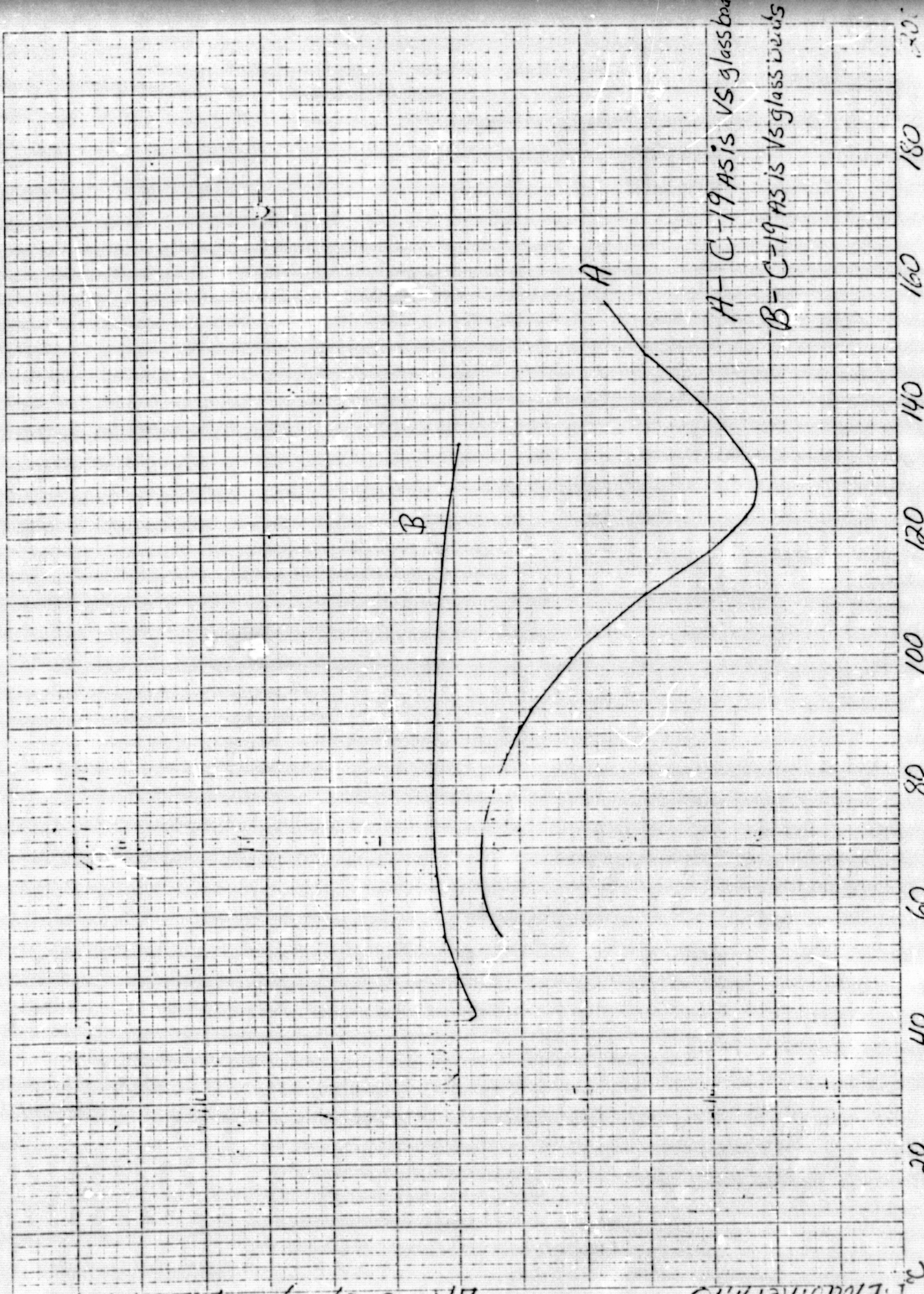
#12 C-19 + 40% KOH vs Glass beads + 40% KOH



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#13

Endothermic
 A-B
 12.25
 → ΔT (0.5 °C/min) → Exothermic

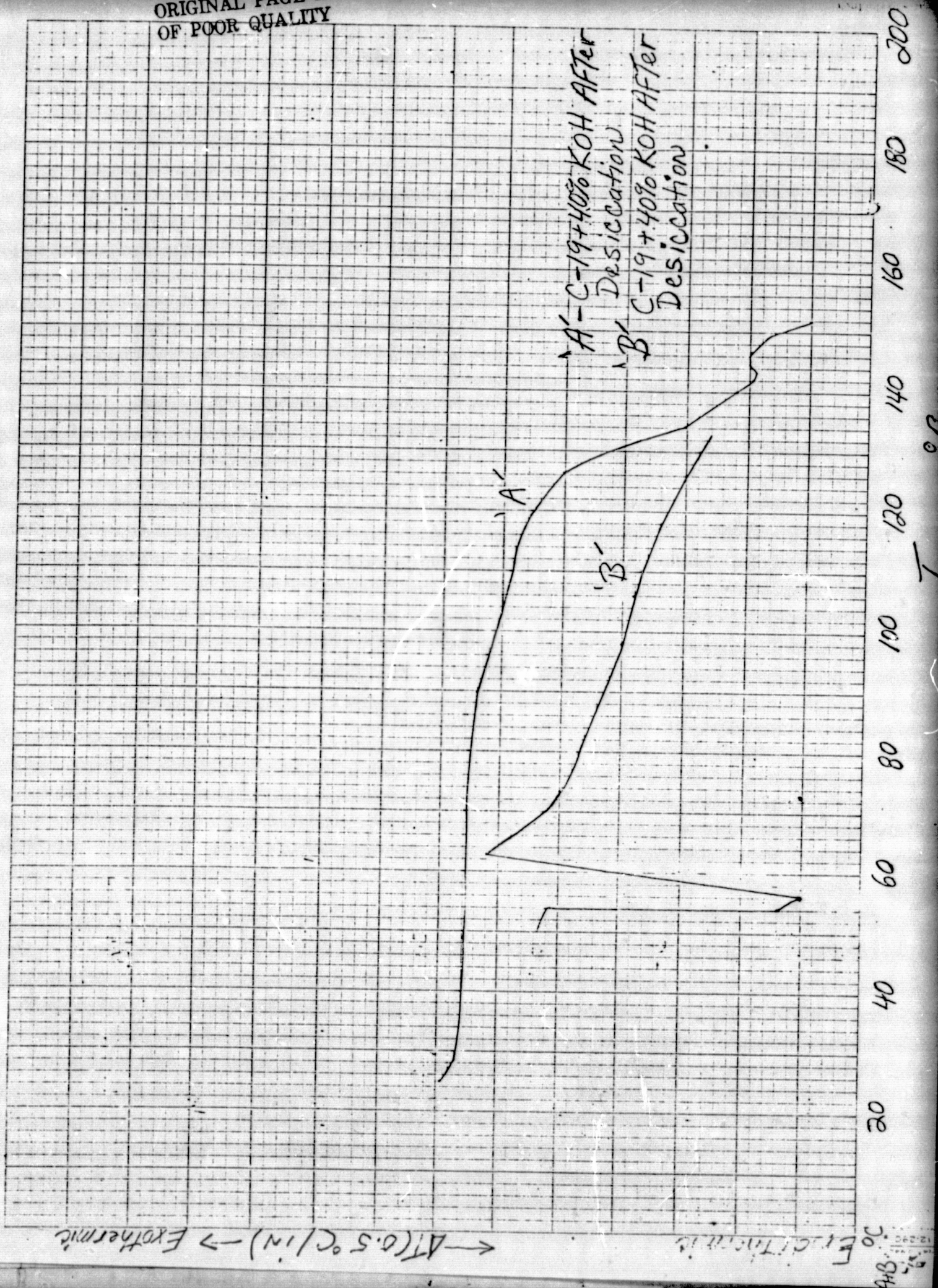


A - C-19 AS is VS glass beads

B - C-19 AS is VS glass beads

Temp °C

14



#15

← $\Delta T (0.5^\circ \text{C/in})$ → Exothermic

Endothermic



A - Cellophane + 40% KOH
After Air Evaporation
Vs Glass Beads

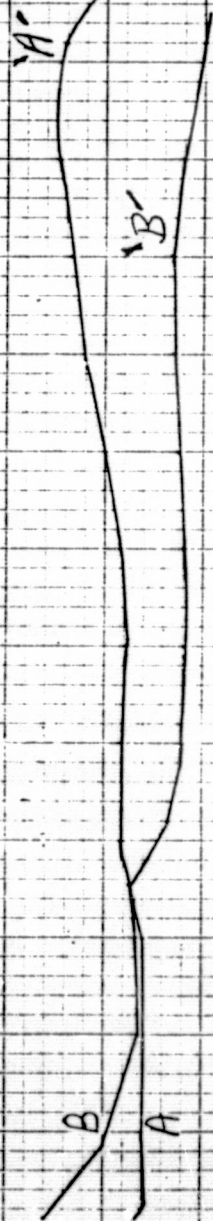
B 'A' Run Recycled

Temp °C

#17

Endothermic
A-B: $\Delta T(0.5^\circ \text{C/ml}) \rightarrow$ Exothermic

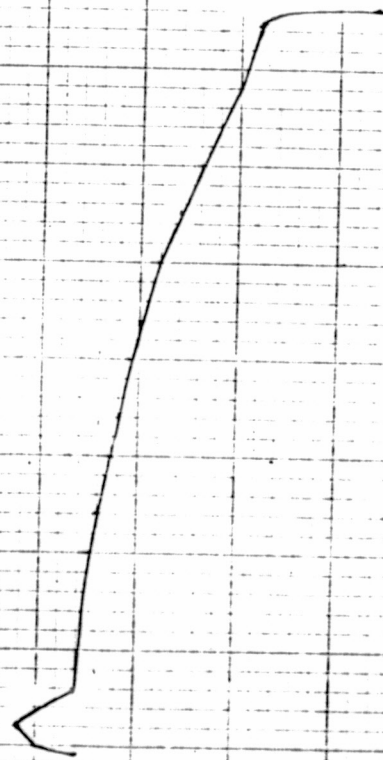
A - C-19 + 40% KOH +
Ag₂O After Des-
iccation
B - Recycled C-19
From A-Retran



20 40 60 80 100 120 140 160 180

#18 C-19-Plain-Vs Glass Beads

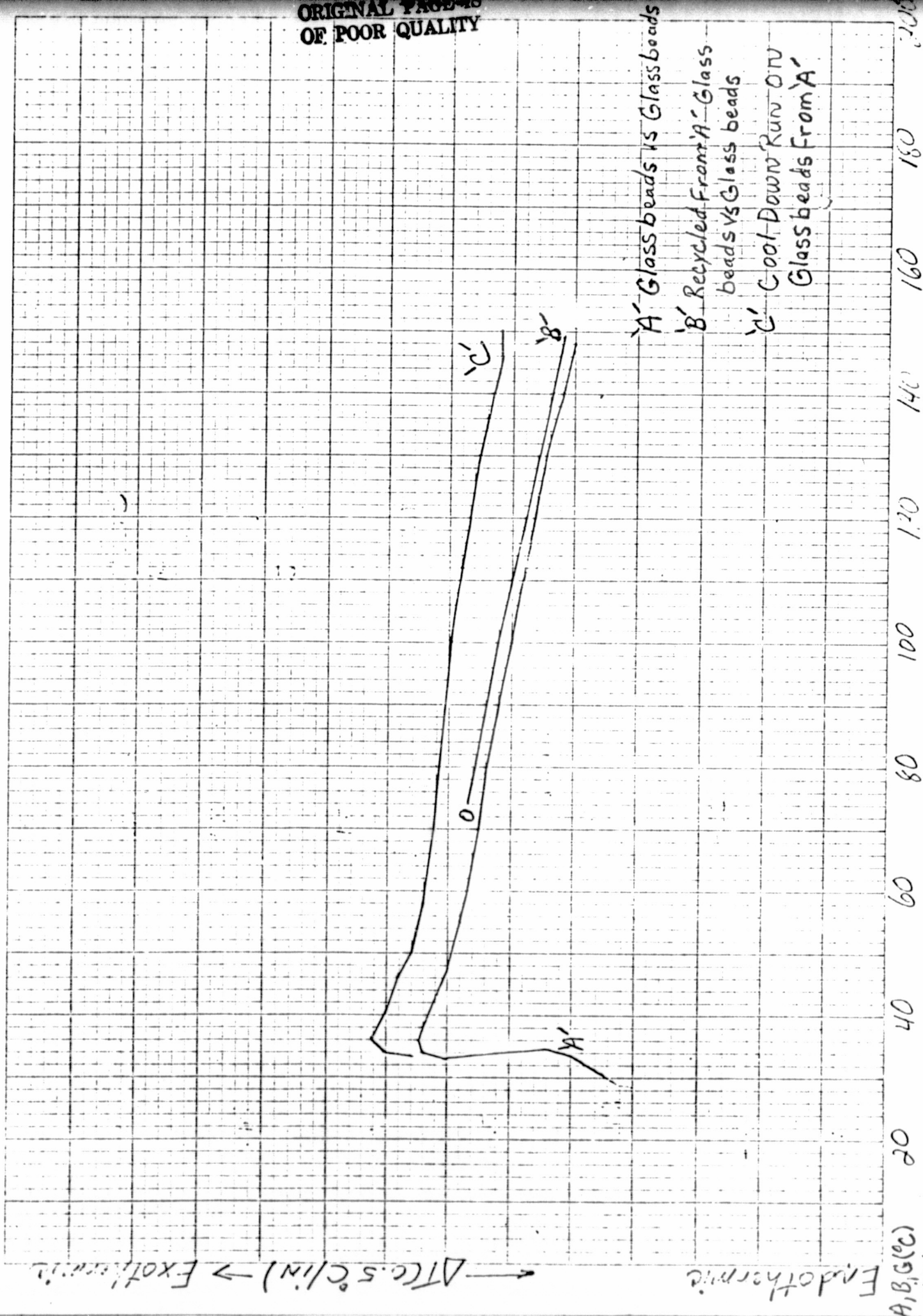
Endothermic
 - $\Delta T (c. 5^\circ C/m)$ $\rightarrow$ Exothermic



(A) C-19 Plain Vs Glass Beads

#19 Glass beads vs Glass beads

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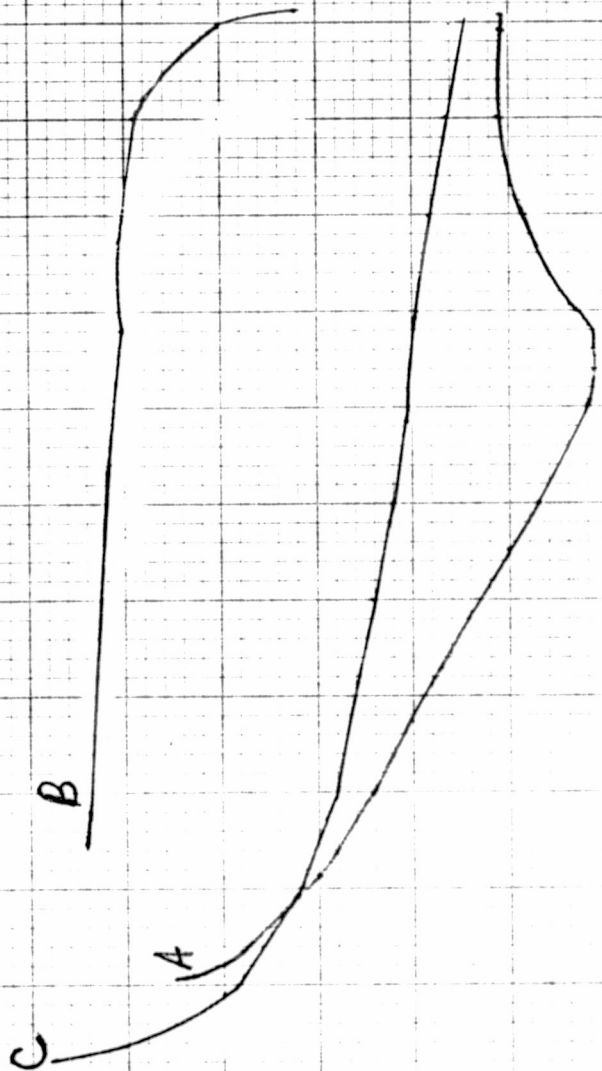
Temp °C

#20

ΔT (0.5 °C/in) $\rightarrow$ Exothermic

Endothermic

ΔT (°C) (1/4 in)



A) Woven Nylon vs Glass beads

B) Cool down run of Woven Nylon vs Glass beads From A

C) Rerun on A After Cool down

200

180

160

140

120

100

80

60

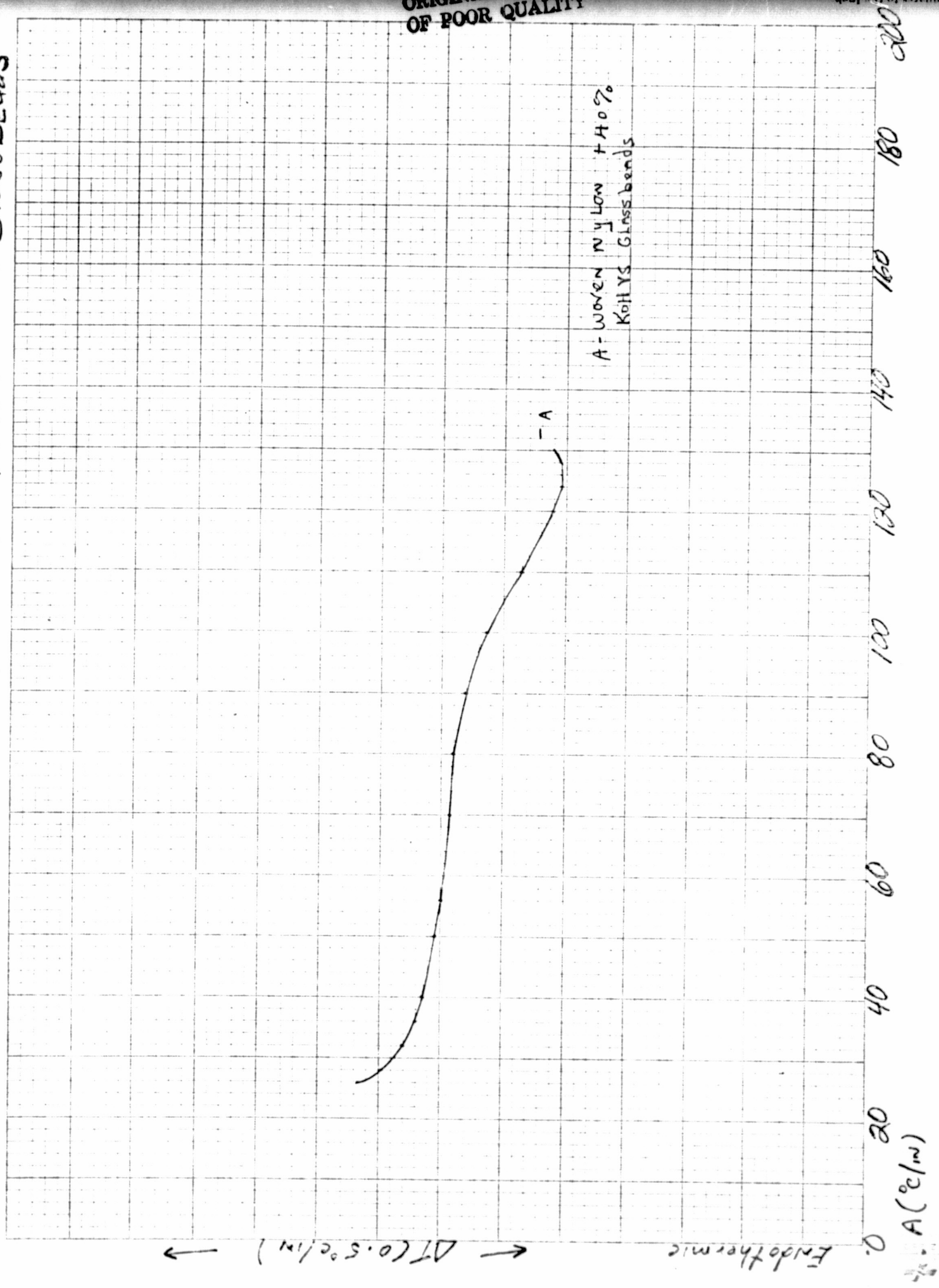
40

20

10 Squares = 1 inch

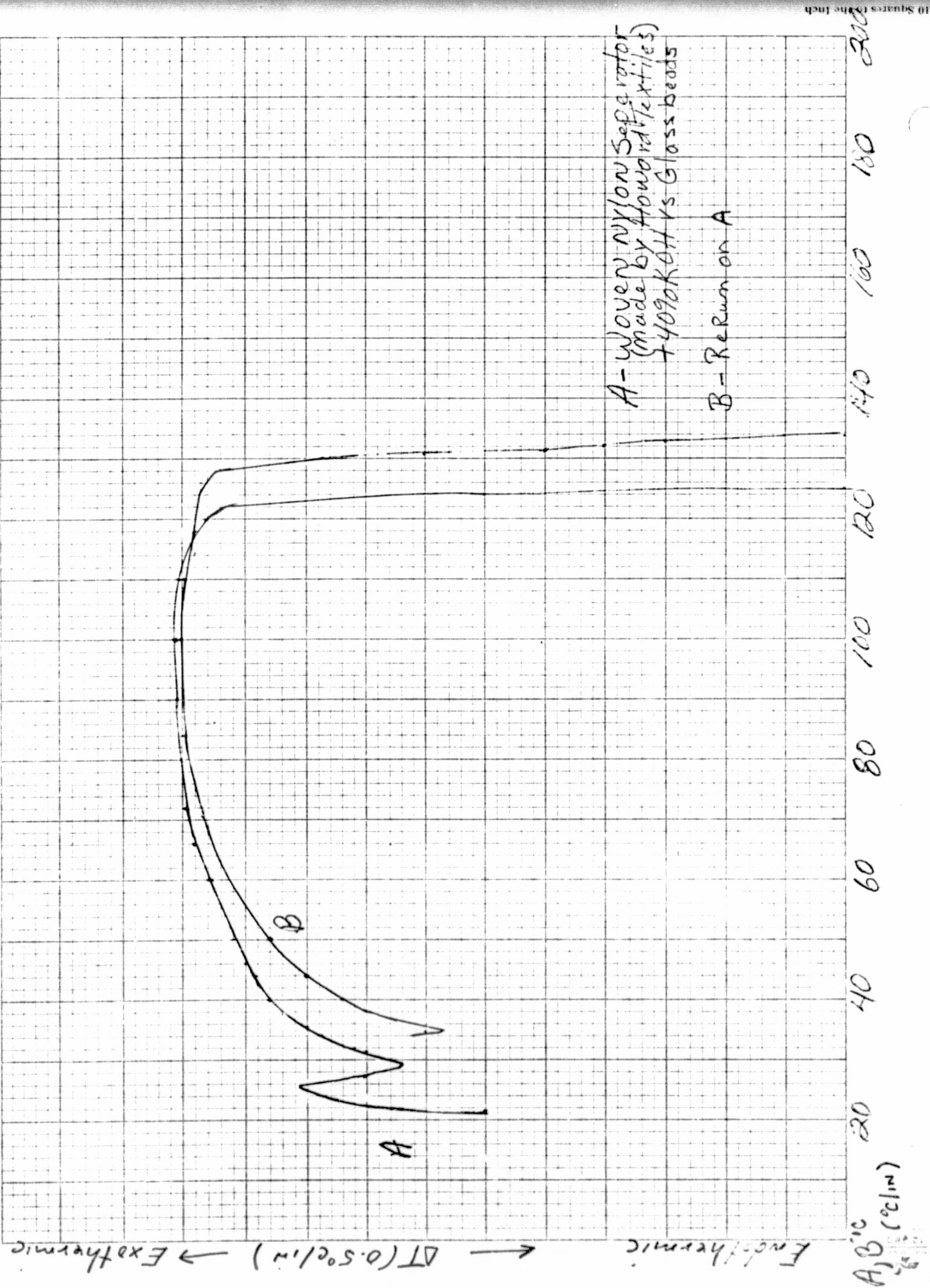
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#21 Woven nylon + 40% KOH vs Glass beads



A - WOVEN NYLON + 40%
KOH VS GLASS BEADS

#22 Woven nylon separator



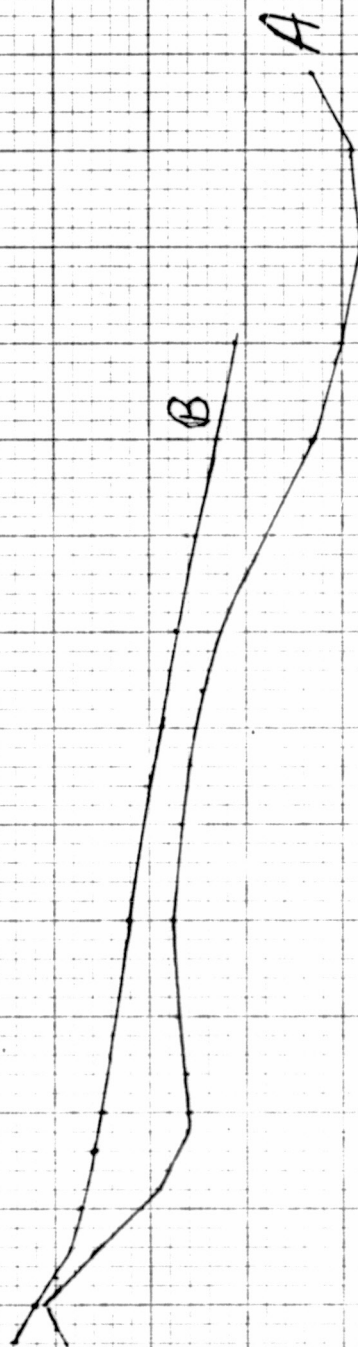
#23 Woven nylon Separator

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→ $\Delta T (0.5^\circ \text{C/m}) \rightarrow \text{ExoThermic}$

EndoThermic

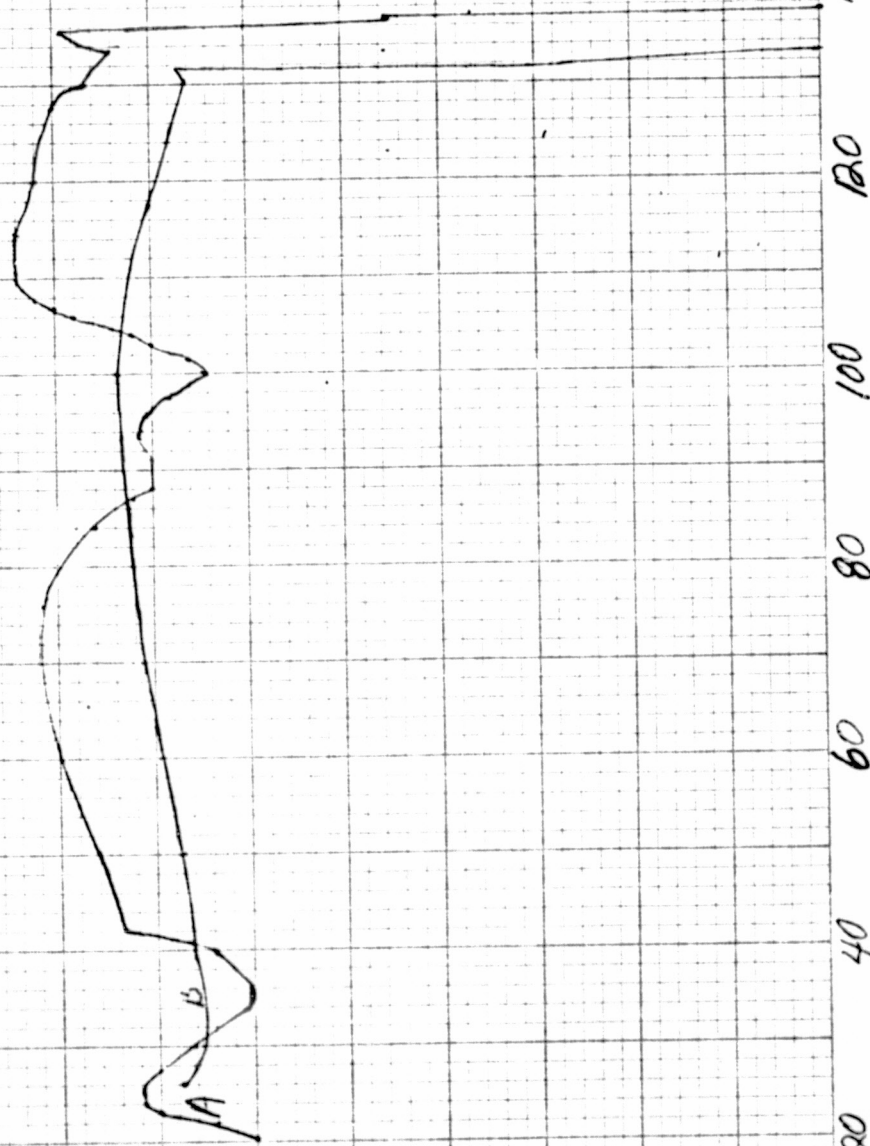
A, B, D (°C/m)



A-Woven nylon
Separator (as
is) Vs Glass
beads
B-Rerun on A

#24 Woven nylon Separator

Endothermic → DT (0.50 cal/m) → Exothermic

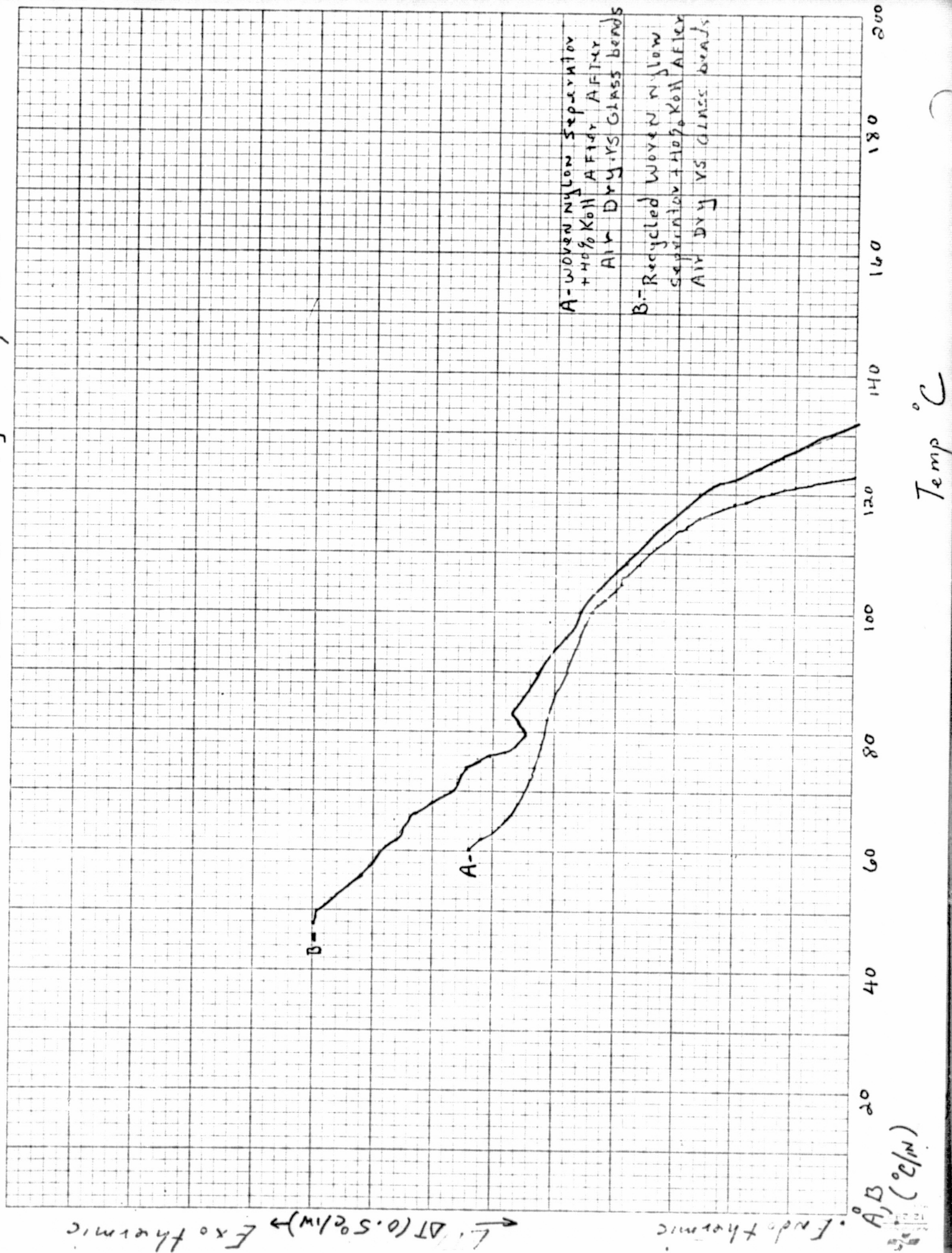


A- Woven nylon Separator
+ 40% KOH After
24 hours Dyeing
VS Glass beads

B- Recycled Woven Sep
VS Glass beads

AB° (°C/m)

25 Woven Nylon Separator



#26

Woven Nylon Separator After 24 hr. Desiccation

DT (0.50 c/w) Exothermic

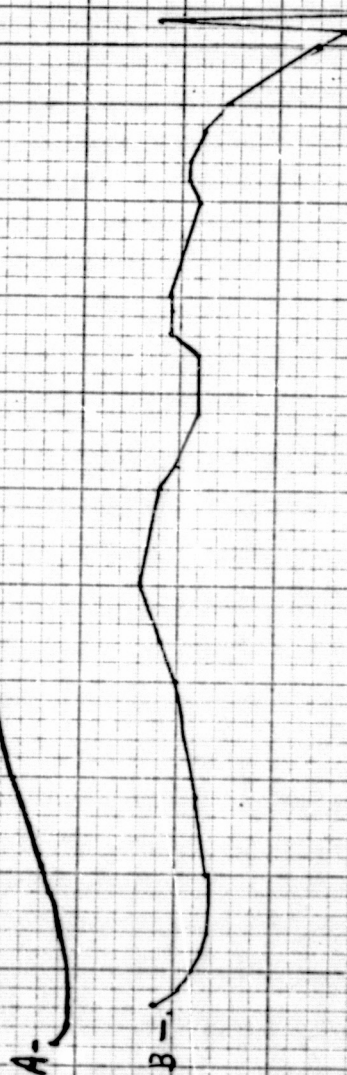
Endothermic

A, B (°C/in)

Temp °

40 60 80 100 120 140 160 180 200

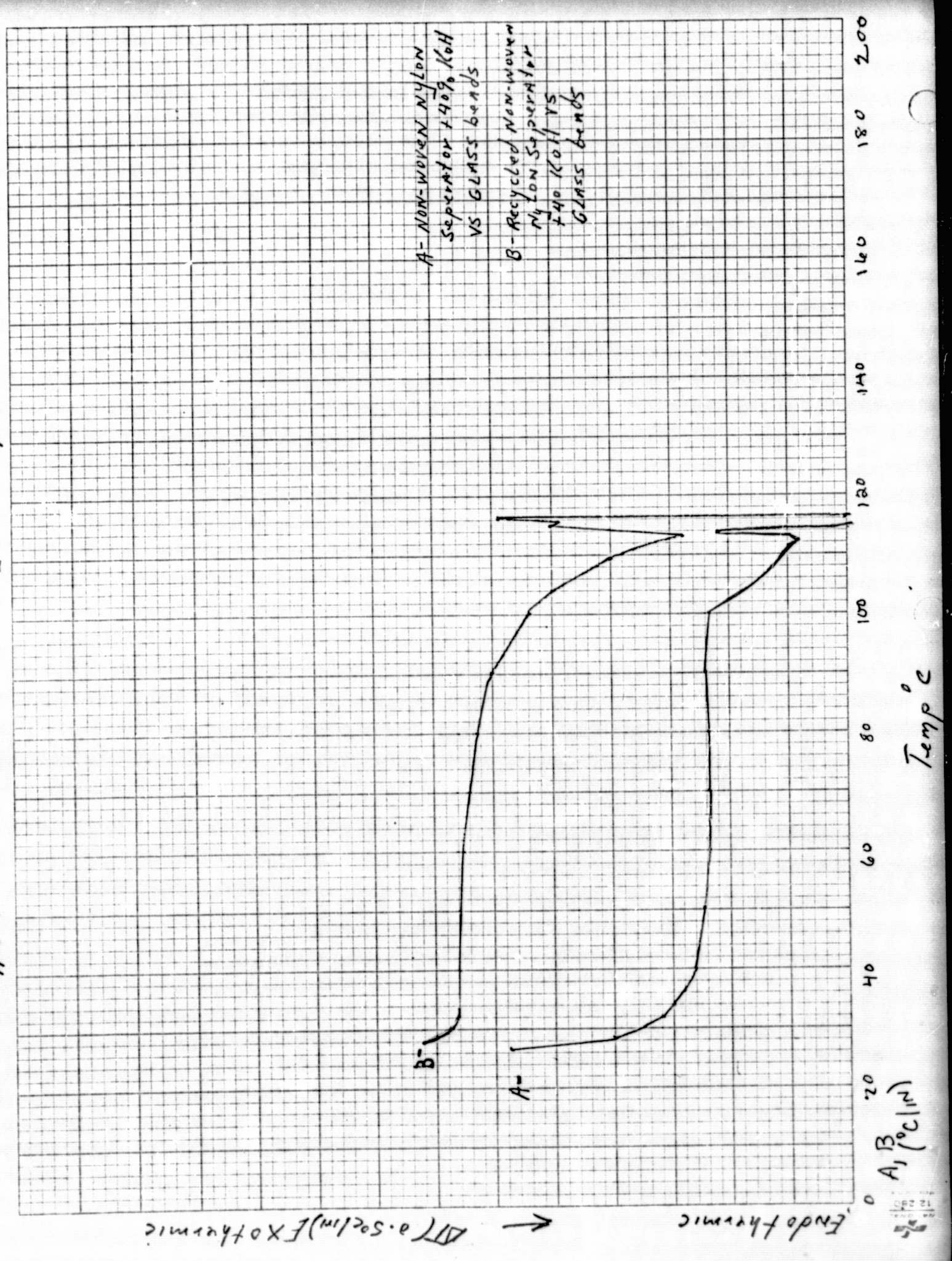
A: Woven Nylon Separator After 40% KOH After Desiccation 24 hr. VS Glass Bands
B: Recycled Woven Nylon Separator + 10% KOH After 24 hr Desiccation VS Glass Bands



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Squares to the Inch

#27 Non-Woven Nylon Separator + 40% KOH



#28 Non-Woven Nylon Separator Plain

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Endothermic → ExoThermic
ΔT (0.50 cal/mg)

A-
B

A- Plain Non-Woven
Separator VS
Glass beads
B- Recycled Plain
Non-Woven
Separator VS
Glass beads

Temp °C

0 A, B (°C/mg)

Endothermic

12.280

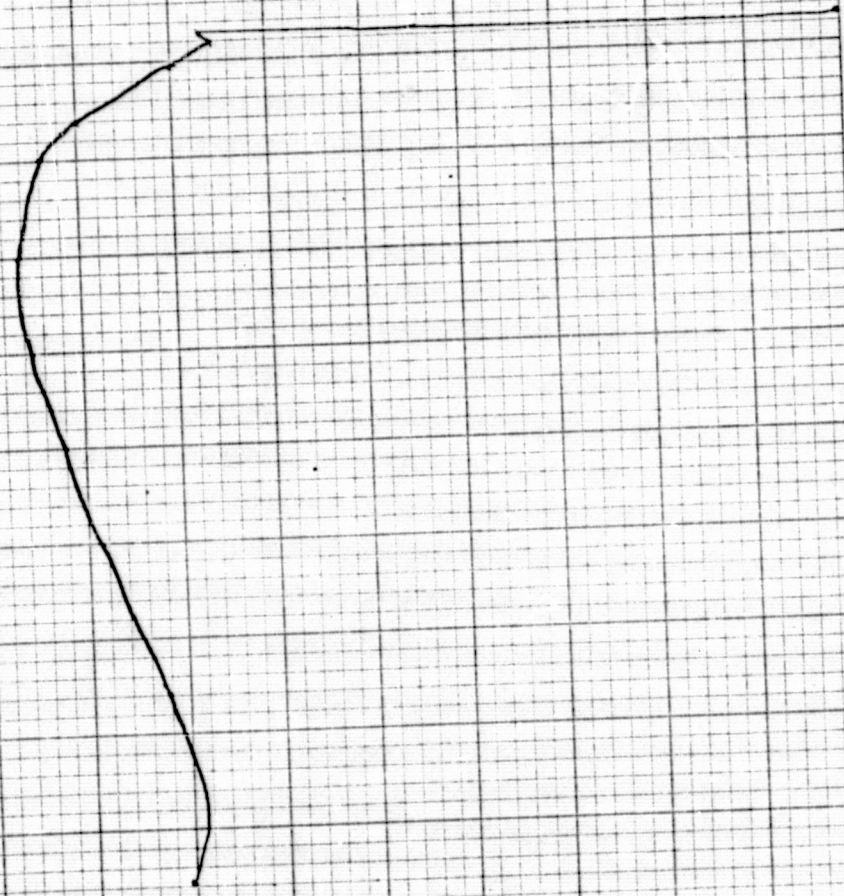
#29 Woven Nylon + 40% KOH

Endo thermic
 ΔT (0.5 cal/mg) Exo thermic

Temp (°C)

Temp °C

A - Woven Nylon
 separator + 40% KOH
 After 48 hrs Air
 Dry VS Glass bond



#131 woven Fibers +40% Roll AFTER 120 hr AIR

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Endothermic → $\Delta T(0.50 \text{ cal/in}) \rightarrow \text{Exothermic}$

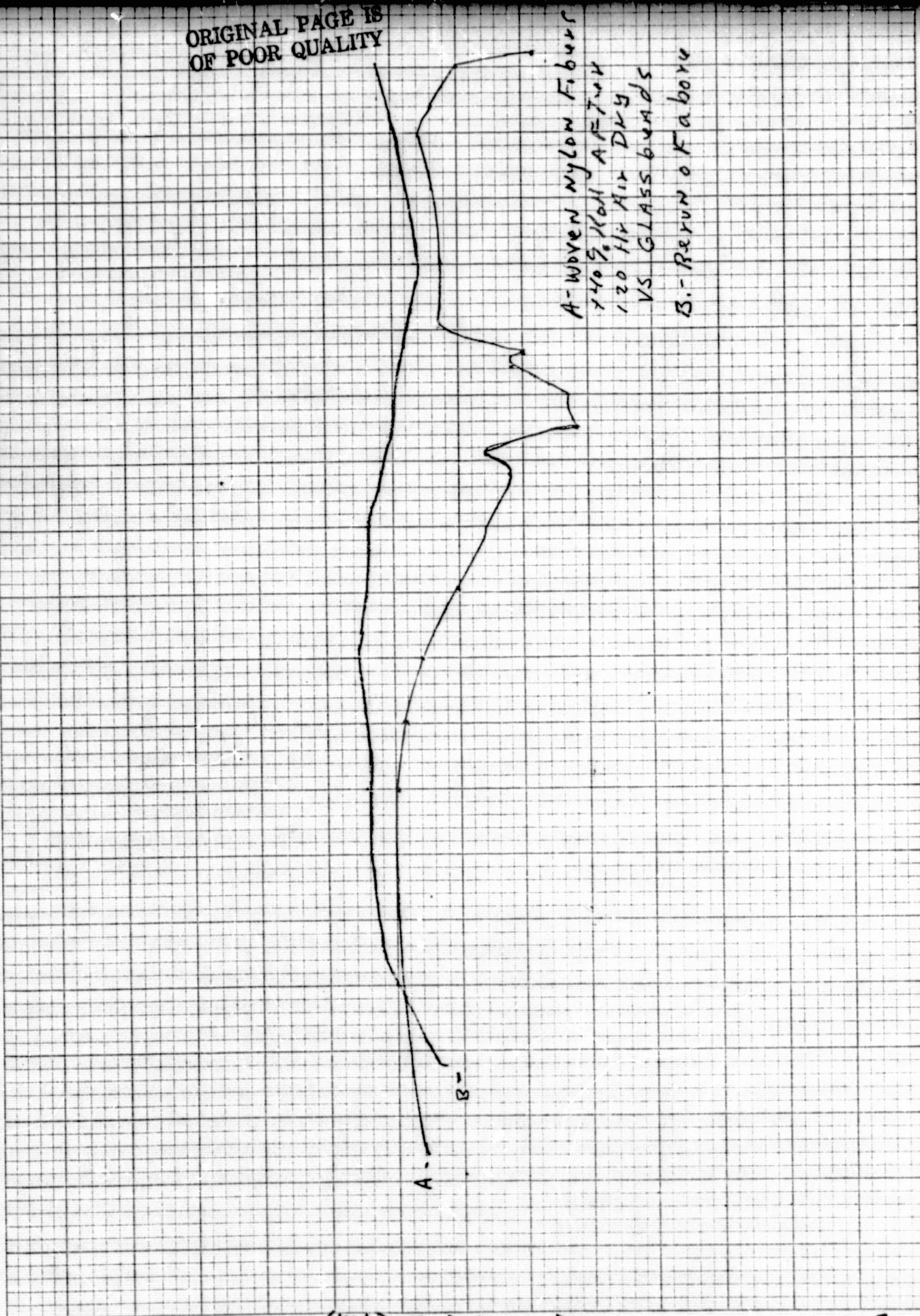
A-
B-

A-Woven Nylon Fibers
+40% Roll AFTER
120 hr AIR DRY
VS GLASS FIBERS
B- Return of Fabric

0 A, B, (°C/in)

Temp °C

20 40 60 80 100 120 140 160 180 200



Non-Woven Nylon

#33

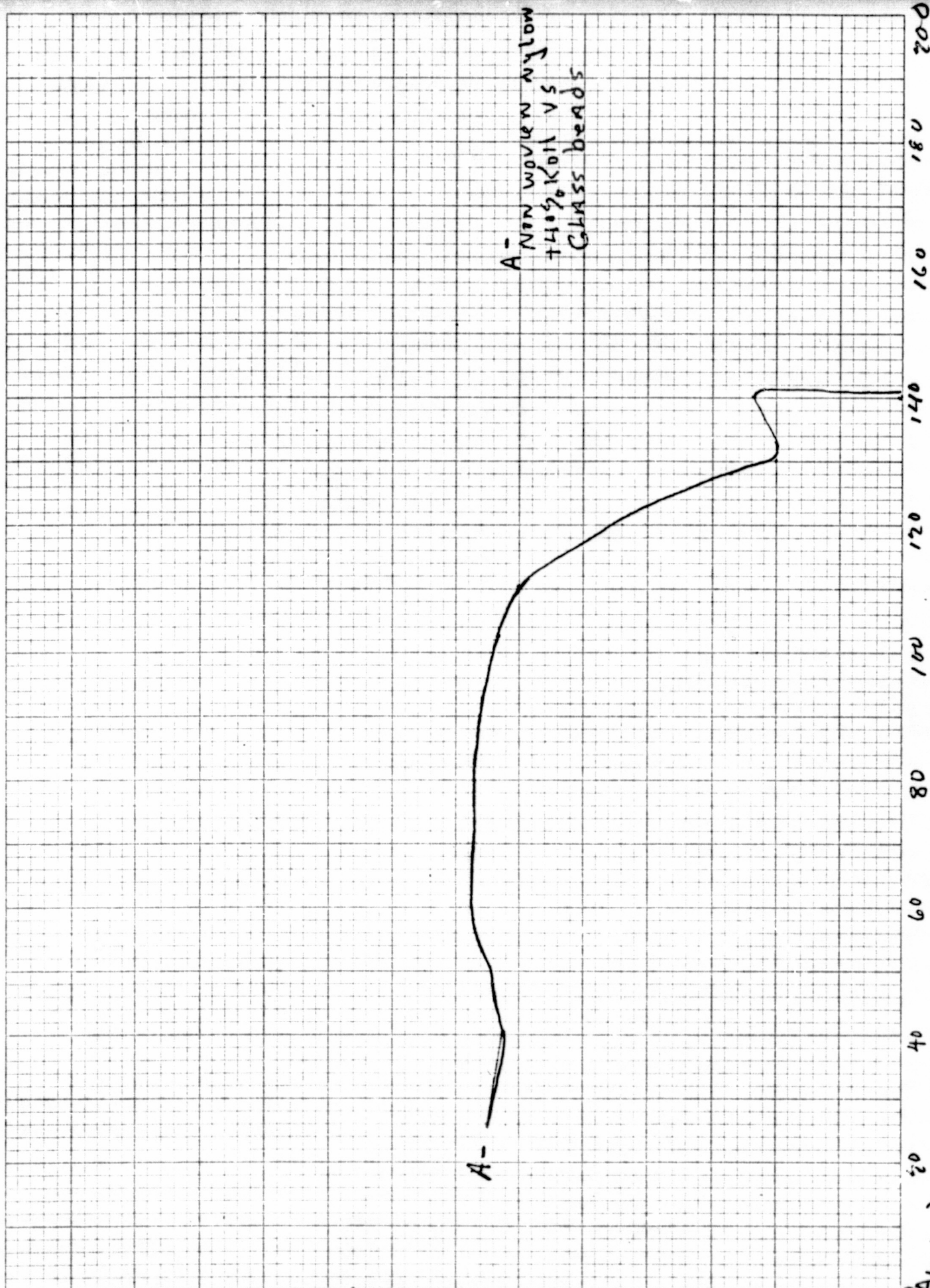
Endo thermic $\rightarrow \Delta T (0.5^\circ \text{C/min}) \rightarrow$ Exo thermic

A-

A- Non woven nylon
+ 40% Koll vs
Glass beads

$\Delta T (^\circ \text{C/min})$

Temp $^\circ \text{C}$

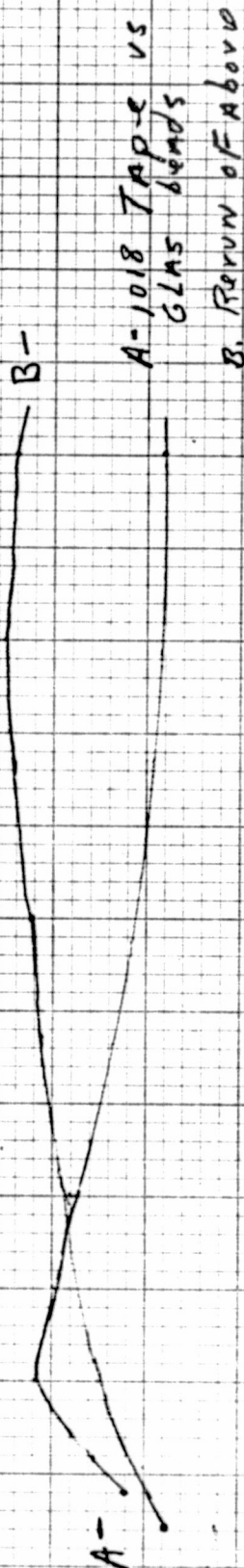


1018 Tape

#34

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Endothermic → ΔT (0.5 cc/in) → Exothermic



0 A, B (°C/in)

1018 Tape From
VITTA Corp.

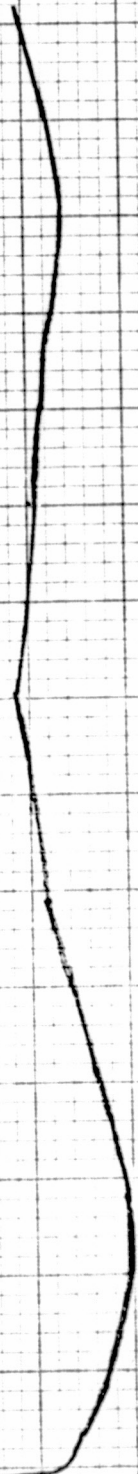
Temp °C

20 40 60 80 100 120 140 160 180 200

0080 TAPV VS GLASS bonds #35

Endo thermic ← DT (0.5 °C/min) → Exo thermic

A-



A-0080 TAPV VS
GLASS bonds

200

180

160

140

120

100

80

60

40

20

0

0080 TAPV
VITTA Corp

Temp °C

A₁ (°C/min)

RK

0080 Tape

#36

Endothermic → $\Delta T (0.5 \text{ cal/m})$ → Exothermic

A-
B

A-0080 Tape vs
CLASS beads
B- Rerun of Above

0 A, B
($^{\circ}\text{C/m}$)

Temp $^{\circ}\text{C}$

20 40 60 80 100 120 140 160 180 200

R.K.

#38

1018 TAPPO

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OF POOR QUALITY

Endothermic → ΔT (0.5°C/m) → Exothermic

B-
A-

A, B (°C/m)

0 20 40 60 80 100 120 140 160 180 200

Temp °C

1018 TAPPO
VITA CORP

RK

A- 1018 TAPPO
VS GLASS
BANDS

B- Review of
above

10 Squares to the Inch

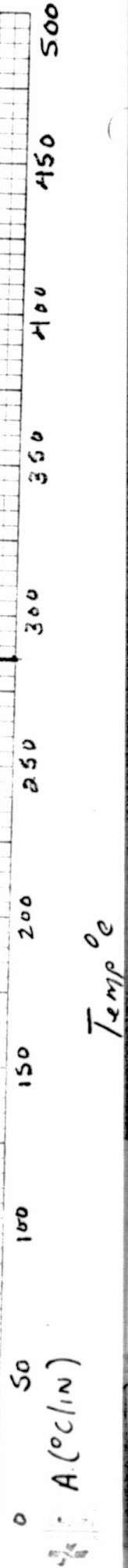
#H₂O (Reference)

Anthraquinone Vs Al₂O₃

Endothermic $\Delta T (0.5^\circ C/in)$ $\rightarrow$ Exothermic

A-Anthraquinone
VS Aluminum Oxide

A.

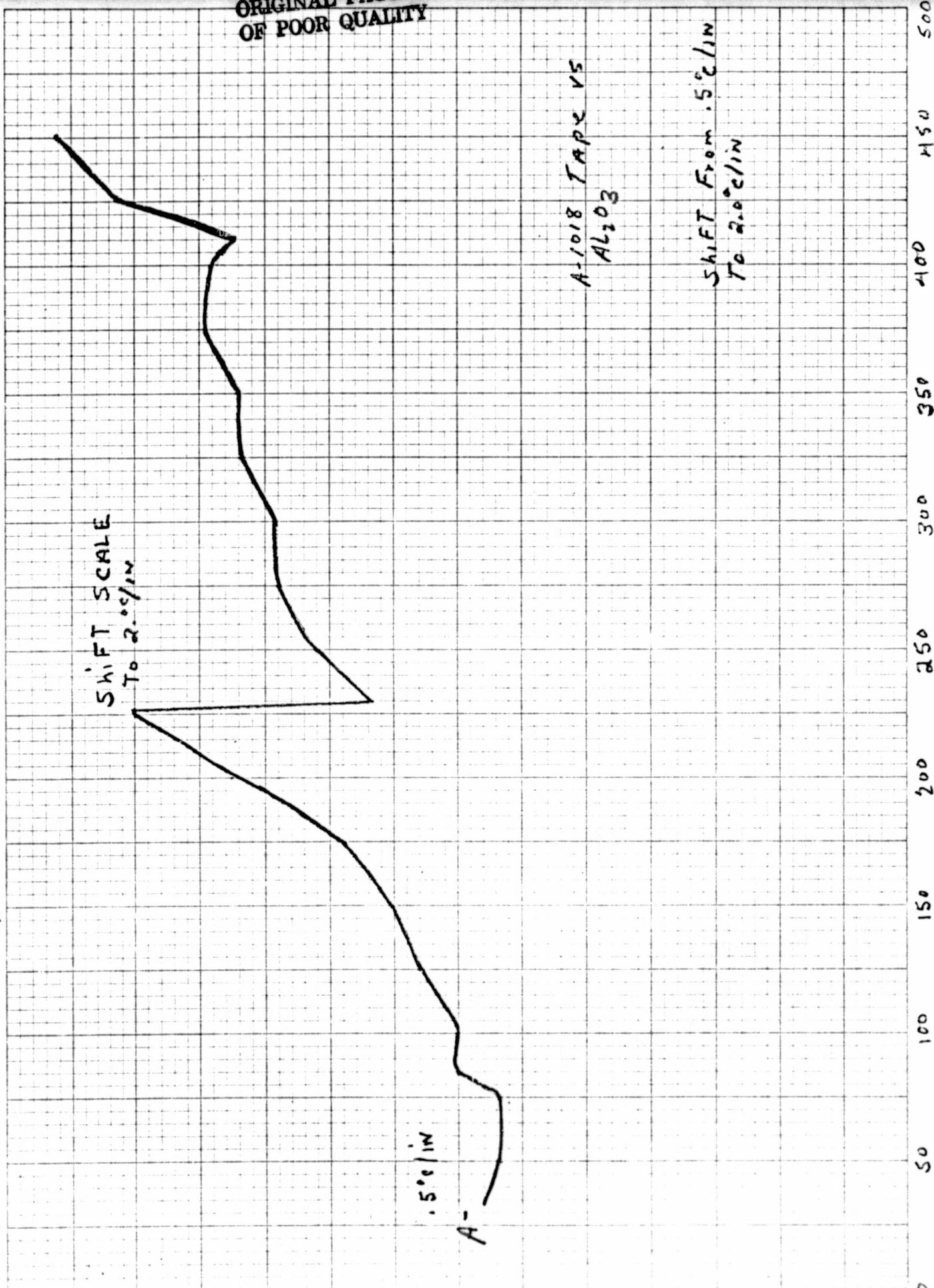


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#41

1018 TAPE VS Al_2O_3

ΔT (0.5°C/in $\rightarrow$ 2.0°C/in) $\rightarrow$ Exothermic



Endothermic

1018 TAPE
vs 1018 TAPE

1018 Tape vs Al_2O_3

#43

Endo thermic ΔT (5.0°C/min $\rightarrow$ 2.0°C/min) $\rightarrow$ Exothermic

SHIFT TO 2.0°C/min

SHIFT TO 2.0°C/min

A- 5.0°C/min
B- 5.0°C/min

A-1018 VS Al_2O_3

B- Review

SHIFT from 0.5°C/min
To 2.0°C/min

Temp °C

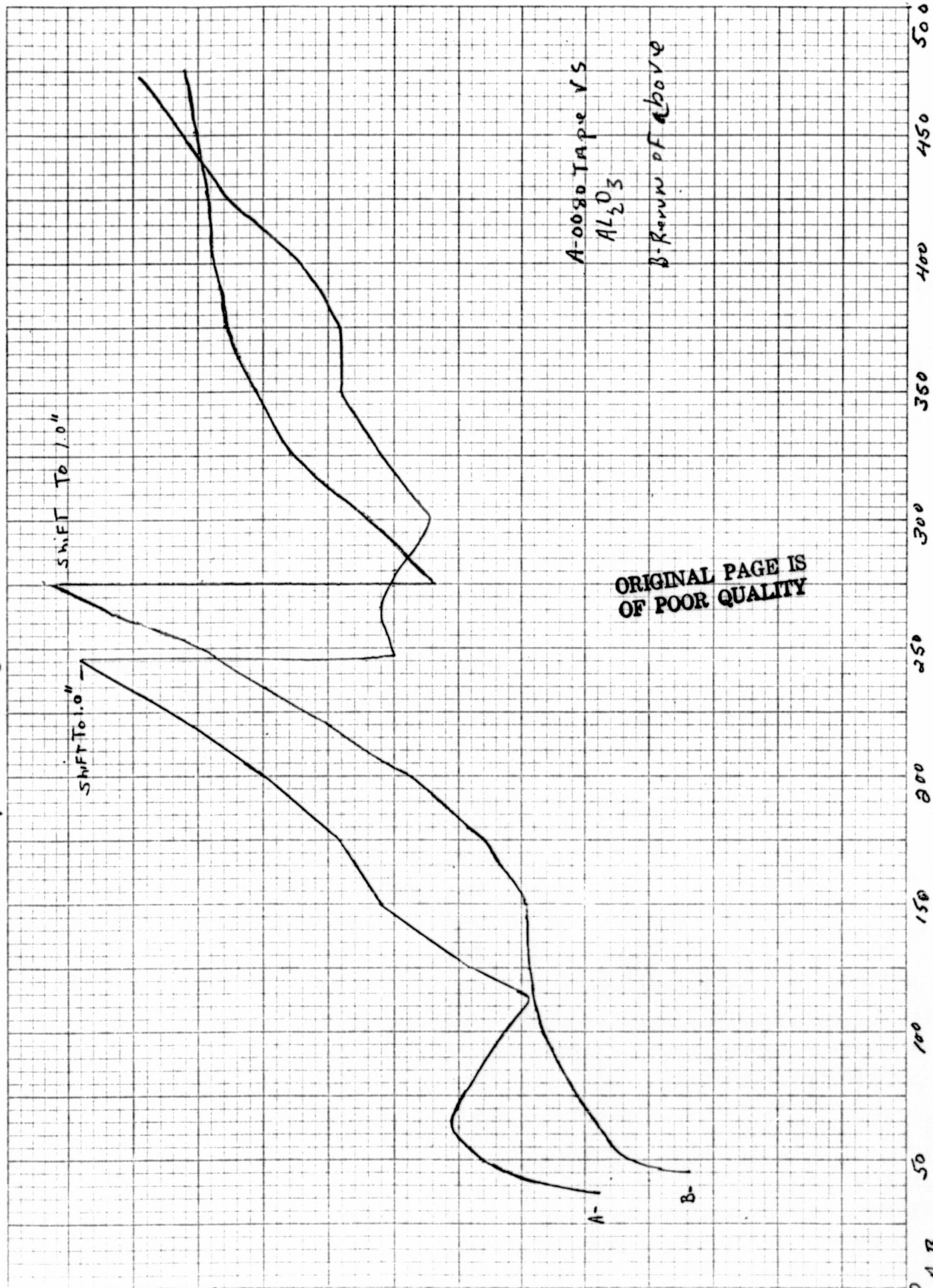
A, B (°C/min)

1018 Tape
VITTA Corp.

RK

#44

0080 Tape Vs Al_2O_3



0080 Tape
VITA Corp.

RK

#45

0080 TAPE VS Al_2O_3

ΔT (.50 cal/m) $\rightarrow$ Exothermic

Endo Thermic

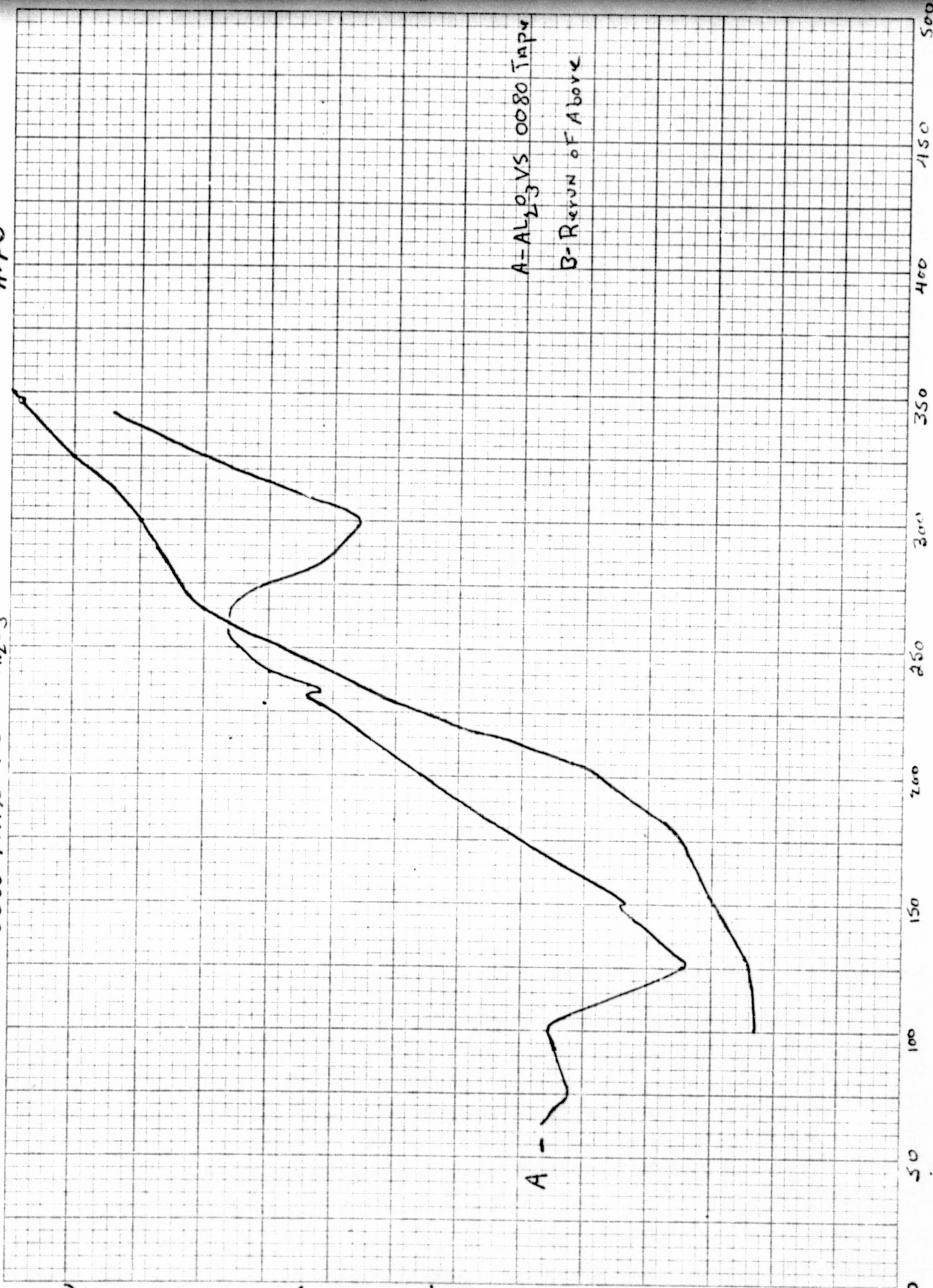
A- Al_2O_3 VS 0080 Tape

B-Run of A above

A, B (cal/m)

Temp °C

0080 Tape



PK

1018 tape vs glass beads

Endothermic → ΔT (5 cal/g) → Exothermic

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A-1018 TAPE vs Glass
beads

ΔT (cal/g)

50 100 150 200 250 300 350 400 450 500



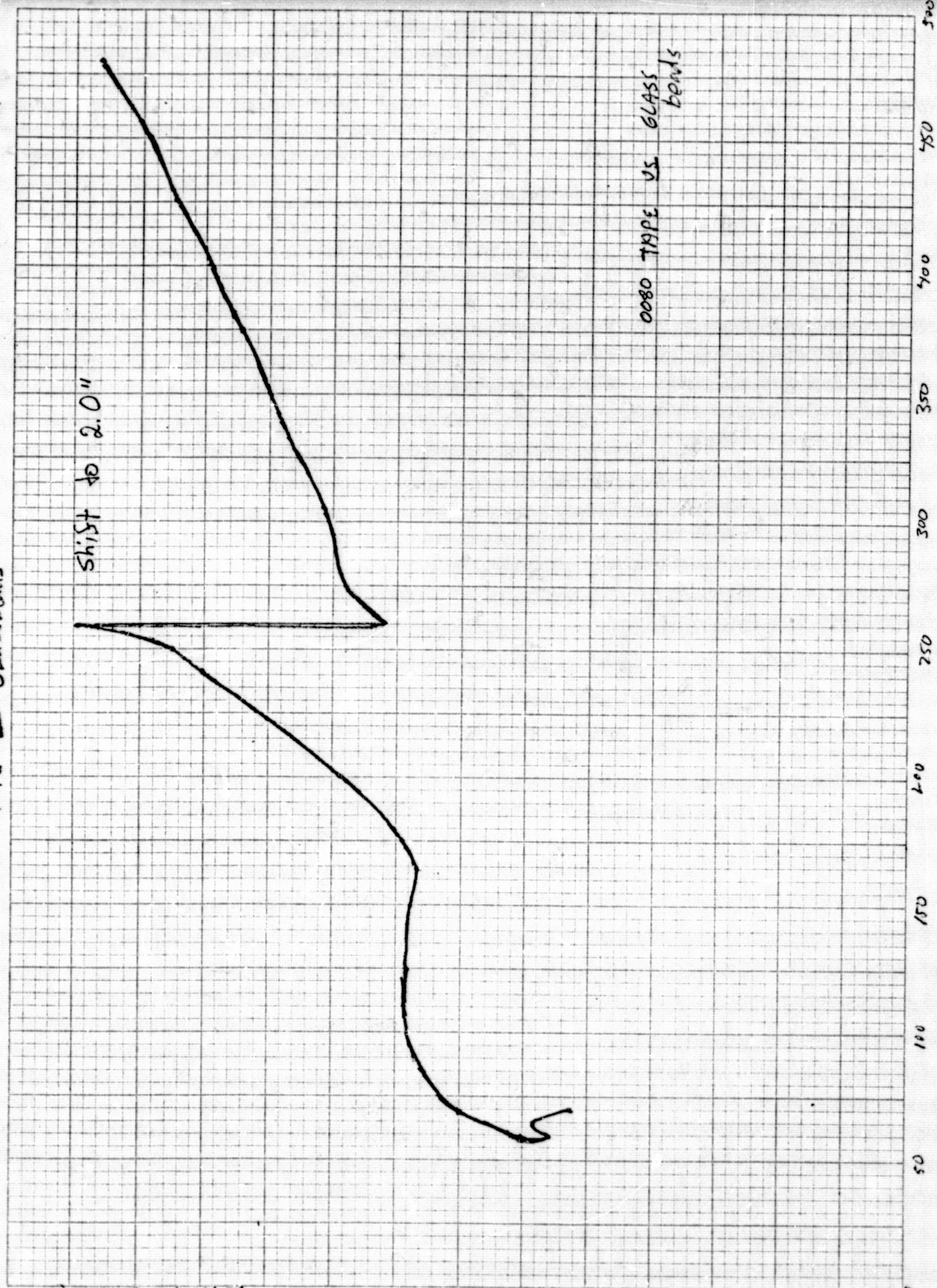
0080 TAPE vs Glassbeads

#48

Endo Thermic ΔT (5 cal/in) $\rightarrow$ Exo Thermic

Shift to 2.0"

0080 TAPE vs GLASS beads



(N/20)

Temp °C

R.K.

10 Squares to the Inch

0080 TAPE vs Glassbeads

#49

ΔT (50 cal/m) → Exo Thermic

Endo Thermic ←

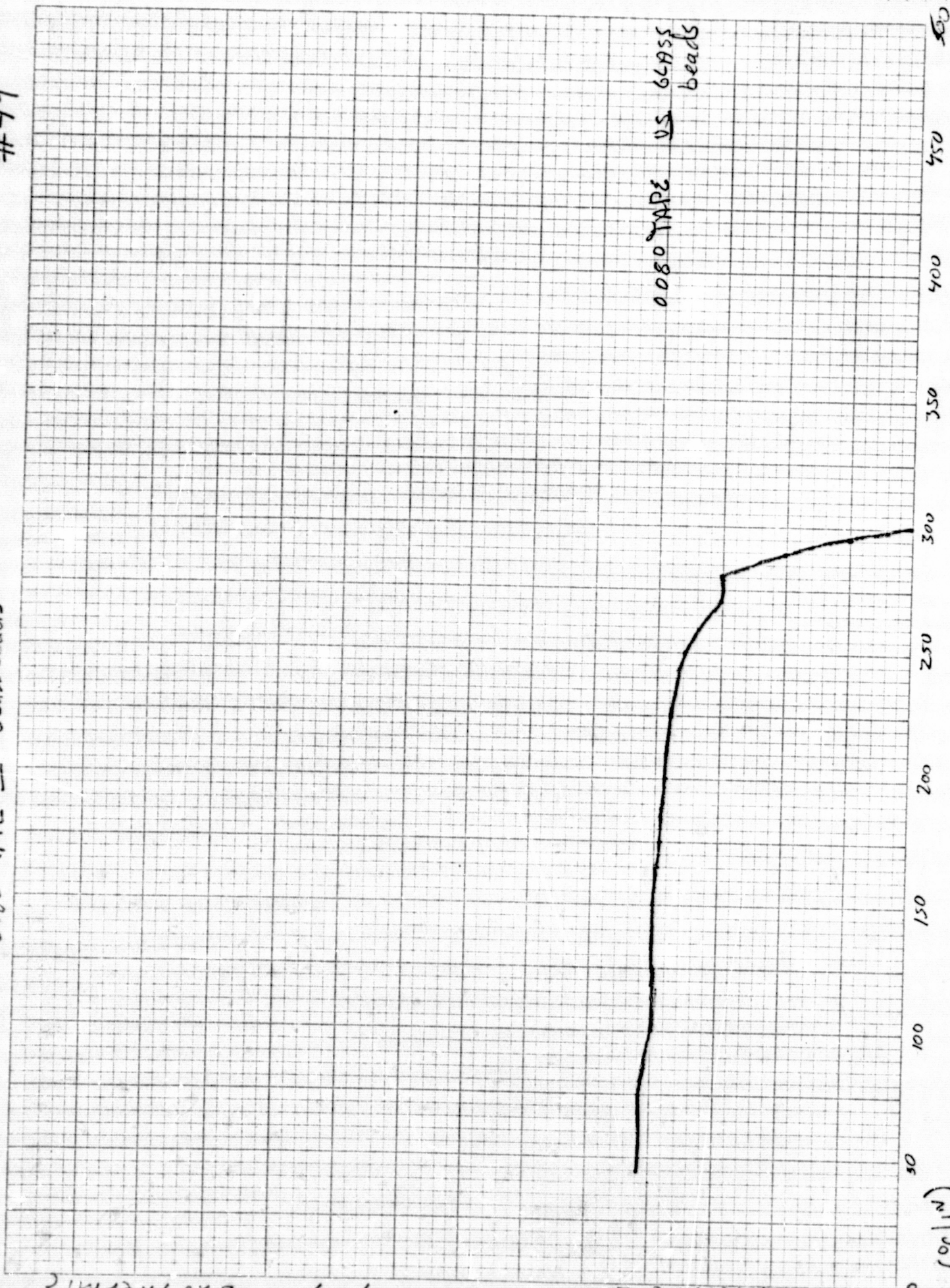
0080 TAPE vs GLASS
beads

ΔT (50 cal/m)

Temp. °C

KX

10 Squares to the Inch



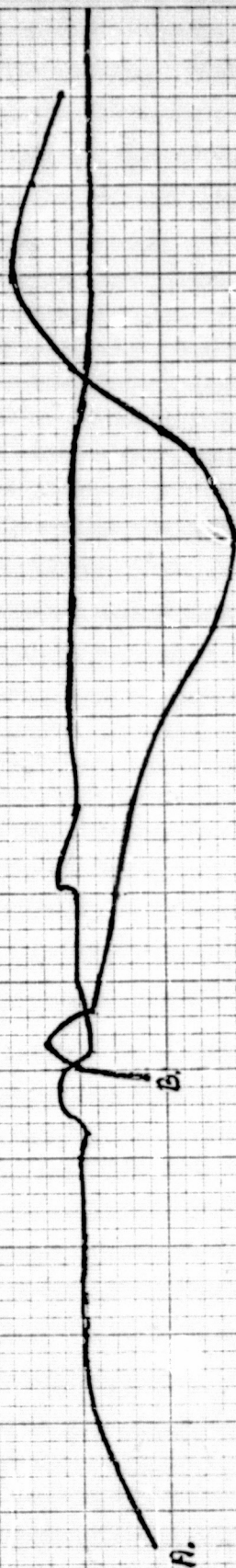
#51

1018 TAPE vs Al_2O_3

→ $\Delta T (0.50 \text{ cal/in}) \rightarrow \text{Exo/thermic}$

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A. 1018 TAPE vs Al_2O_3
B. Runn vs Above



Temp C

RK

S-383-70 SILICON VS GLASS beads #54

RUN FROM -175°C TO
Room Temp.

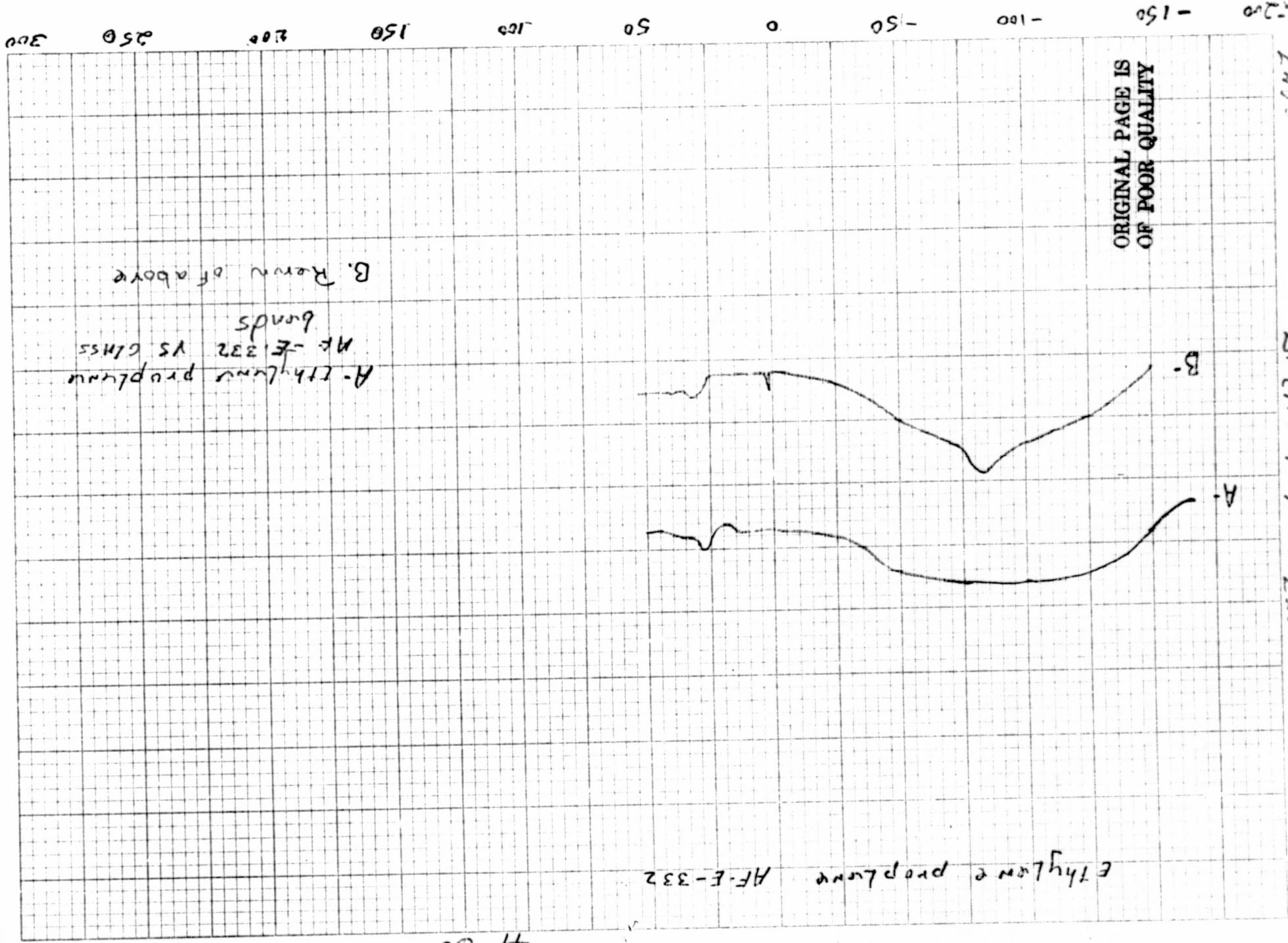
- A- S-383-70
SILICON VS
GLASS beads
B- Rerun of Above
C- Rerun of Above



AFB

Endothermic ← $\Delta T (1.0^\circ C/min)$ → Exothermic

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A. Ethylene propylene
AF-E-332 VS CHSS
bands
B. Run of above

Ethylene propylene AF-E-332

60

Fig 1

Endothermic $\leftarrow \Delta T (1.0^\circ \text{C/in}) \rightarrow$ Exo Thermic

-200

A, B



A - Ethylene Propylene
E-515-80 VS GINSBENDS

B - RUN OF ABOVE

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7762

Endo thermic → AT (1.0°C/min) → Exo thermic

200
A & B



A-Ethylene Propylene
AF-E-332 VS Glass bands
Pulverized, top of
sample cell sealed
with Type L Apiezon
grease